WPS5731

Policy Research Working Paper 5731

Who Uses Bottled Gas?

Evidence from Households in Developing Countries

Masami Kojima
Robert Bacon
Xin Zhou

The World Bank
Sustainable Energy Department
Oil, Gas, and Mining Unit
July 2011

Policy Research Working Paper 5731

Abstract

Household surveys in Guatemala, India, Indonesia, Kenya, Pakistan, and Sri Lanka were analyzed using a two-stage Heckman model to examine the factors influencing the decision to use liquefied petroleum gas (stage 1) and, among users, the quantity consumed per person (stage 2). In the first stage, liquefied petroleum gas selection in all six countries increased with household expenditure and the highest level of education attained by female and male household members. Electricity connection increased, and engagement in agriculture and increasing household size decreased, liquefied petroleum gas selection in five countries; urban residence increased selection in four countries; and rising firewood and kerosene prices increased selection in three countries each. In the second stage, the quantity of liquefied petroleum gas consumed increased with rising household expenditure and decreasing price of liquefied petroleum gas in every country. Urban residence increased and engagement in agriculture decreased liquefied petroleum gas consumption. Surveys in Albania, Brazil, Mexico, and Peru, which did not report quantities, were also examined by calculating quantities using national average prices. Although fuel prices faced by individual households could not be tested, the findings largely supported those from the first six countries. Once the education levels of men and women were separately accounted for, the gender of the head of household was not statistically significant in most cases across the ten countries. Where it was significant (five equations), the sign of the coefficient was positive for men, possibly suggesting that female-headed households are burdened with unmeasured economic disadvantages, making less cash available for purchasing liquefied petroleum gas.

This paper is a product of the Oil, Gas, and Mining Unit, Sustainable Energy Department. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at mkojima@worldbank.org.

Who uses bottled gas? Evidence from households in developing countries

Masami Kojima
World Bank

Robert Bacon
World Bank

Xin Zhou
George Mason University

JEL codes: D12

Keywords: LPG, liquefied petroleum gas, household surveys, biomass, fuel, cooking, energy poverty, Heckman, education, gender

---

The authors are, respectively, Lead Energy Specialist in the Sustainable Energy Department, consultant, and Ph.D. student. The authors are grateful to the Norwegian Agency for Development Cooperation for funding this study through its Petroleum Governance Initiative under the Oil for Development program. The paper benefited from helpful comments provided by John Newman, Nistha Sinha, Roy Van der Weide, and Ariel Yepez-Garcia, all of the World Bank.

Who uses bottled gas? Evidence from households in developing countries

1. Introduction

Globally, energy poverty—lack of access to electricity and continuing reliance on traditional use of solid fuels for cooking and heating—is widespread: an estimated 1.4 billion people live without electricity, and about 2.7 billion use biomass and another 400 million use coal for cooking or heating. Forecasts have suggested that, on unchanged policies, the number of people without electricity will decline little while absolute numbers relying on biomass may actually increase over the next twenty years (UNDP and WHO 2009; IEA 2010).

The damage to health caused by traditional household use of solid fuels has been well documented. In one of the most detailed global assessments to date, the World Health Organization reported in 2002 that, in the year 2000, about 1.6 million—more than the number of deaths from malaria in that year—had died from indoor smoke from combustion of solid fuels, and that females and children under the age of five had higher risks of death. Indoor air pollution had also caused various illnesses amounting to 38.5 billion disability-adjusted life-years (DALYs), more than four-fifths of which had been borne by under-five children (WHO 2002). In a subsequent publication, these numbers were raised to 1.9 million deaths and 40.5 billion DALYs for 2004 (UNDP and WHO 2009). In addition, where biomass is collected, the time burden on the collectors—many of whom are women and children—can be considerable, taking children away from attending school and studying at home, depriving parents of time that could otherwise be spent on childcare, and denying adults alternative productive activities, including income generation. Where biomass is not harvested sustainably, its use can lead to degradation or loss of tree resources. While expansion of agriculture, not use of woodfuels (firewood and charcoal), remains the primary driver of deforestation globally, concentrated consumption of woodfuels—typically in urban areas by residential users as well as by industry—can lead to loss of forest cover (FAO 2009; PREDAS 2009).

Switching to a cleaner-burning commercial fuel[1] is one way of reducing the health cost of indoor smoke, the time burden associated with fuel collection, and the pressure on biomass resources. Although dependent on the stove technology, in general, gaseous fuels—natural gas, biogas, and liquefied petroleum gas (LPG)—burn more cleanly than liquid fuels (the most common of which for household use is kerosene), and liquid fuels burn more cleanly than solid fuels, although kerosene burning in a wick stove (in contrast to a high-pressure stove, which gasifies kerosene first) may emit more smoke than biomass burning in an advanced-combustion stove.

There are several barriers to shifting households from a solid fuel to a gaseous fuel. In terms of availability, kerosene is more widely available than LPG, and LPG more than natural gas, which enjoys economies of scale and is essentially an urban fuel. Biogas production requires

[1] The use of electricity for cooking is not common in developing countries although in some, such as South Africa and several countries in Eastern Europe and the former Soviet Union, many households use electricity as the primary source of energy for cooking. In others, electricity is increasingly used for cooking rice, boiling water, and powering microwave ovens, but reliance on electricity as the main source of energy for cooking is typically restricted to a very small share of households.

dung from farm animals, limiting its use. For the foreseeable future, LPG will likely remain the most widely available gaseous fuel as well as the most common alternative to biomass for cooking in developing countries. Unless heavily subsidized, kerosene, LPG, and natural gas are typically more expensive than solid fuels, particularly biomass which can be acquired at no financial cost through collection by household members in many parts of the developing world. Where the entry of these household members into the labor force is difficult, the opportunity cost of the time spent collecting can be very low, making biomass collection a financially attractive choice. Cash income, necessary for regular fuel purchase, can also be irregular, particularly in rural areas. It is not surprising that many low-income rural households choose biomass as their main cooking fuel and rarely use LPG even when it is available. Urban households face different circumstances—incomes tend to be higher and more regular, LPG is likely to be more widely and conveniently available, and biomass may no longer be free but has to be purchased—and use LPG more than their rural counterparts.

When trends on fuel use across different income groups are examined, as incomes rise, there is both a *substitution* effect—shifting some households away from biomass to LPG and other cleaner-burning commercial fuels—and an *income* effect for those choosing to use biomass, in which consumption initially rises with income. The income effect may initially dominate at lower income levels and the total use of biomass for the group may increase, while at higher income levels the cumulative effect of households switching away from biomass eventually leads to an overall reduction in its use when averaged across all households (Barnes, Krutilla, and Hyde 2005; Bacon, Bhattacharya, and Kojima 2010). These observations are described as fuel stacking, in which households use several fuels, adding extra fuels as incomes increase (Masera, Saatkamp, and Kammen 2000).

Bacon, Bhattacharya, and Kojima (2010) reported that, out of six countries for which information on the primary cooking fuel was available, more than half of the top two urban quintiles in two countries and more than half of the top two rural quintiles in five countries named biomass as their primary cooking fuel. These findings indicate that availability and affordability, although very important, may not be the sole determinants of fuel choice and use, and that the use of solid fuels for household energy is not always a result of poverty but occurs over a broad income range in developing countries. Gaining a better understanding of the factors that determine household fuel use patterns is important for setting appropriate policies to shift households away from biomass to LPG and other cleaner-burning options.

The foregoing discussion raises two separate questions: (1) What factors influence the household's decision to use a gaseous fuel or electricity (where it is used for cooking and heating) to meet household energy needs? (2) For those households that have decided to use cleaner forms of household energy, what determines the amount of their use? National household expenditure surveys provide a large amount of information on households as well as their total expenditures and patterns of expenditure on energy sources. To carry out a comparative analysis of different fuels, fuel use would need to be standardized on a common basis—for example, gigajoules of *usable* energy delivered by each fuel—because bundles of firewood and kilograms (kg) of LPG are not directly comparable nor can they be added for those using both fuels. Further, a number of surveys do not ask for information on the quantities of dung or collected firewood consumed. Calculating the amount of usable energy requires not only the energy

content and the quantity of each fuel but also the efficiency of the stove and other appliances used. Because kerosene and LPG are uniform in energy content and the variation in the efficiency of stoves for these fuels is relatively narrow, it is possible to make a reasonable comparison of the use of these fuels in terms of usable energy delivered and cost per unit of usable energy (see Bacon, Bhattacharya, and Kojima 2009 for an example of comparison of household use of kerosene and LPG). This general observation also holds for natural gas. In contrast, the efficiency of stoves for biomass spans a much wider range for the purpose of calculating usable energy. Without detailed information on the fuel itself and on the appliances, it is not possible to carry out quantitative analysis—for example, how much of the total usable energy consumed by a household is derived from firewood, dung, charcoal, kerosene, LPG, and/or natural gas. Such information, however, is rarely collected and never in national household surveys.

What is possible with data supplied by national household surveys is detailed analysis and econometric testing of kerosene, LPG, and natural gas. This study focuses on LPG in a group of countries where, with one exception, it is the most commonly used clean form of energy for cooking and heating, and examines its uptake and consumption. Identification of potential factors influencing a household's decision to use LPG and how much to use could help formulate policies that encourage LPG use and reduce energy poverty, as both economic and non-economic circumstances change.

2. Study purpose and coverage

The objective of this study is to identify and assess the quantitative importance of the different factors that lead households to use LPG. Using national household surveys conducted in recent years, this study focuses in particular on competition from biomass. The factors that determine whether a household may choose to use LPG (decision 1, or selection) may be different from those that determine how much LPG the household will consume if it has chosen to use it (decision 2, or consumption). To account for this possibility, a two-stage process is used to explain these decisions separately. The data requirements to carry out this analysis fully are demanding. This study examines six household surveys with the requisite data and sufficient LPG users. Four additional surveys, which did not report quantities consumed but where national average LPG prices were available from other sources, are also analyzed to conduct more limited modeling of selection and consumption.

Section 3 brings together evidence on the use of LPG and of solid fuels as the primary cooking fuel in 110 developing countries. Section 4 covers econometric analysis of household use of LPG in 10 developing countries. Section 5 discusses the findings of the study in the context of policy options for encouraging the increased uptake and consumption of LPG.

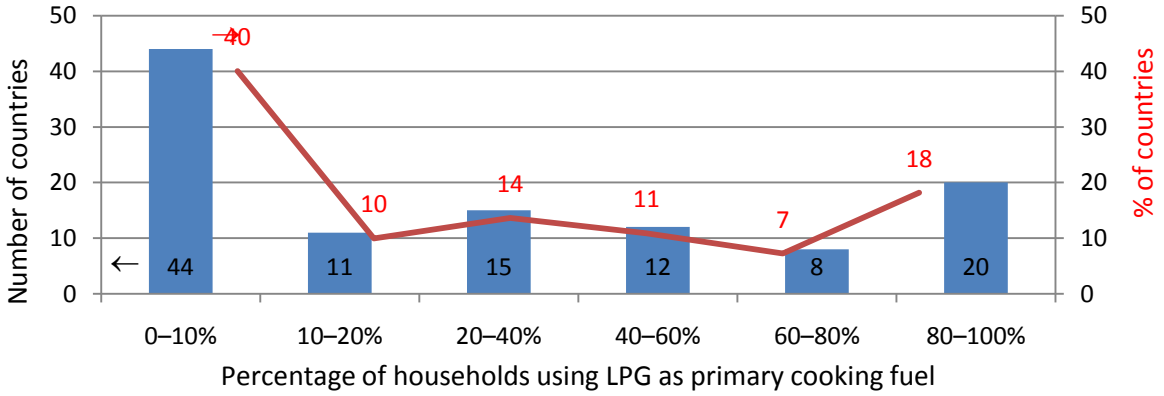
3. Evidence on household use of LPG and biomass for cooking in developing countries

The World Health Organization (WHO) maintains an extensive database of household energy use for cooking, drawing upon information collected on the primary cooking fuel in nationally representative surveys of households. Results are presented nationally and for urban

and rural households separately, but information is not given at a wealth/income quintile level. Two sets of health-related surveys provide information by wealth quintile. The third round of the Multiple Indicator Cluster Survey (MICS3) of UNICEF, carried out in more than 50 countries, provides information on the main cooking fuel used by households by wealth index quintile and also for urban and rural households separately (UNICEF various years). The surveys do not identify households using LPG as a secondary cooking fuel or for non-cooking purposes. A series of World Bank reports based on the findings of the Demographic and Health Surveys conducted between 1990 and 2005 in 56 countries (World Bank various years) gives data on the use of LPG as a main cooking fuel by quintile group for some countries not covered by MICS3. A further small group of countries not covered by these sources have provided information, derived from national household expenditure surveys, on the use of LPG as a cooking fuel by expenditure quintile. Table A1.1 in appendix 1 provides information on the degree of use of LPG and of solid fuels as the principal cooking fuel in 110 developing countries where this information has been gathered since 2000. The range of LPG use for cooking varies from virtually universal to none, as does the range of solid fuel use. With the exception of Cambodia, Haiti, and the Lao People's Democratic Republic, all countries with near-universal use of solid fuels for cooking are in Sub-Saharan Africa. The share of households using LPG in most cases is higher in urban than in rural areas. This trend is reversed in seven countries on account of urban household use of natural gas.

Figure 1 plots the distribution of LPG adoption rates across the 110 countries. Of the 44 countries where less than one-tenth of households reported using LPG as the primary cooking fuel, 29 countries were in Sub-Saharan Africa. In about a dozen countries with less than half of the households citing solid fuels as the primary cooking fuel, other forms of clean energy sources were important: kerosene in Djibouti and Indonesia; natural gas in Belarus, the Kyrgyz Republic, the Russian Federation, Ukraine, and Uzbekistan; and electricity in Bhutan, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Montenegro, Serbia, South Africa, and Tajikistan. In 30 percent of the countries, more than half of the households named LPG as their primary cooking fuel.

Figure 1: Country statistics for LPG as primary cooking fuel

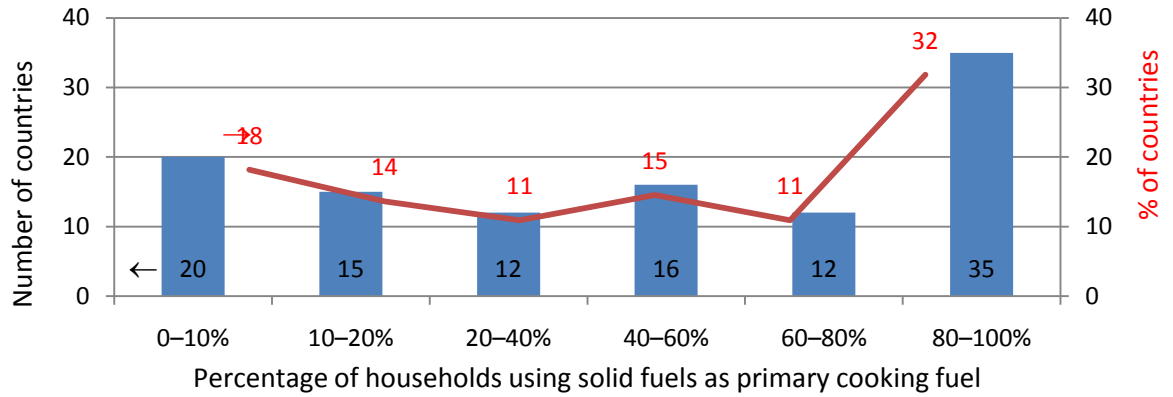


Source: Authors' calculations.

Figure 2 provides evidence on the use of solid fuels, which are usually the main competitor to LPG in countries where neither natural gas nor electricity is widely used. At one

end of the spectrum, households in one-third of countries have largely switched to a cleaner alternative and fewer than 20 percent of households use solid fuels as their principal cooking energy source. At the other end of the spectrum, in half the countries, more than half of the households rely on solid fuels for cooking. In a handful of countries—Angola, Botswana, Nicaragua, Paraguay, the Philippines, Senegal, and Tonga— households are almost equally divided between using LPG and using solid fuels (Table A1.1 in appendix 1).

Figure 2: Country statistics for solid fuels as primary cooking fuel



Source: Authors' calculations.

The data on LPG use by wealth/income quintile show that there are three separate trends that may be part of an overall pattern (Table 1):

Type A countries where the use of LPG increases steadily with rising quintile. Fifty one of the 63 countries in the table follow this pattern. The share of households using LPG as the primary cooking fuel is often very much greater in the top quintile than in the bottom quintile, suggesting that there is scope for a substantial increase in the uptake of LPG in the future as both incomes and the fuel's availability increase.

Type B countries where the use of LPG declines with rising quintile. There are four countries in this category. In Belarus and Ukraine, a large share of the households in the lowest quintile uses LPG, but the share declines to virtually nothing in the top quintile because of the availability of natural gas. In Uzbekistan where natural gas also dominates household fuel use, the share of households using LPG declines from a mere 3 percent to 2 percent with rising quintile. In Trinidad and Tobago, LPG use is nearly universal in the lower quintiles but is substituted by electricity in the top quintile, in which the share of households using LPG falls to 78 percent.

Type C countries, which appear to bridge types A and B. The use rate initially increases with quintile level and then declines. Eight countries follow this pattern.

Table 1: Percentage of households using LPG as primary cooking fuel by quintile

Region	Country	Source	Q1	Q2	Q3	Q4	Q5	Type
Asia	Bangladesh+ (2006)	MICS3	0	0	0.3	4.3	48	A
	Cambodia	HH surveys	0	0.2	0.5	1.7	20	A
	India	HH surveys	0.5	2.3	7.2	21	65	A

Region	Country	Source	Q1	Q2	Q3	Q4	Q5	Type
	Indonesia+ (2002–03)	DHS	0.1	0.3	1.4	5.4	47	A
	Lao PDR	MICS3	0	0	0	0	3.5	A
	Mongolia	MICS3	0	0	0.2	7.9	98	A
	Nepal (2001)	DHS	0	0	0	0	13	A
	Sri Lanka	This study	1.0	3.9	9.2	18	44	A
	Thailand	MICS3	8	41	69	88	97	A
	Vanuatu	MICS3	0	0	0.5	4.2	58	A
	Vietnam	MICS3	0	1.9	6.1	41	88	A
ECA	Albania	MICS3	2.1	11	23	51	70	A
	Armenia (2000)	DHS	1.6	14	15	25	45	A
	Belarus	MICS3	76	41	5	0.4	0	B
	Bosnia and Herzegovina	MICS3	0.6	3.1	5	5.8	14	A
	Georgia	MICS3	0.4	2.5	17	29	9.8	C
	Kazakhstan	MICS3	27	56	59	43	20	C
	Kyrgyz Republic	MICS3	0.3	4.6	8.2	22	7.7	C
	Macedonia, FYR	MICS3	0.2	2	0.2	3.4	6.3	A
	Montenegro	MICS3	1	3.3	2.5	3	0	C
	Serbia+	MICS3	5.7	17	23	17	9.7	C
	Tajikistan	MICS3	0.1	0.7	0.8	4.5	13	A
	Turkmenistan+	DHS	85	99	98	99	99	A
	Ukraine	MICS3	27	8.1	5.3	1.1	0	B
	Uzbekistan	MICS3	3.1	2.8	2.9	3	2.1	B
LAC	Belize	MICS3		68			98	A
	Bolivia+ (2003)	DHS	0.5	30	84	96	97	A
	Colombia (2005)	DHS	9.8	53	59	46	32	C
	Dominican Republic	MICS related	32	85	93	97	99	A
	Guyana	MICS3	6.2	17	39	72	95	A
	Mexico	This study	51	78	85	88	84	C
	Nicaragua (2001)	DHS	0	0.9	13	56	94	A
	Peru	This study	6.2	28	58	78	84	A
	Suriname	MICS3	50	80	88	97	99	A
	Trinidad and Tobago	MICS3	95	99	96	95	78	B
MNA	Egypt, Arab Rep.+ (2000)	DHS	21	87	98	99	100	A
	Morocco*	DHS	100	100	100	100	100	A
	Syrian Arab Rep.	MICS3	96	98	98	98	99	A
	Yemen, Republic	MICS3	0.8	36	79	94	99	A
SSA	Benin (2001)	DHS	0	0	0	0	3.6	A
	Burkina Faso	MICS3	0	0	0	0	17	A
	Burundi	MICS3	0	0	0	0.1	0.5	A
	Cameroon	MICS3	0	0	0.1	4.5	62	A
	Central African Republic	MICS3	0	0	0	0	0.3	A
	Côte d'Ivoire	MICS3	0	0.1	0.3	10	58	A
	Ethiopia	DHS	0	0	0	0	0.3	A
	Gabon (2000)	DHS	0.3	37	83	94	97	A
	Gambia, The	MICS3	0	0.1	0.6	2.6	7.9	A
	Ghana	MICS3	0	0	0.5	5.1	44	A
	Kenya	HH surveys	0.1	0	0.1	0.4	12	A
	Malawi	MICS3	0	0	0	0	0	A
	Mali (2001)	DHS	0	0	0	0	1.3	A

Region	Country	Source	Q1	Q2	Q3	Q4	Q5	Type
	Mauritania	MICS3	0	2.6	27	62	86	A
	Mozambique (2003)	DHS	0	0	0	0	9.2	A
	Namibia (2000)	DHS	0	0	5.8	27	12	C
	Nigeria	MICS3	0	0	0	0	2.2	A
	Rwanda (2000)	DHS	0	0	0	0	0.2	A
	São Tomé and Principe	MICS3	0	4.5	20	37	63	A
	Somalia	MICS3	0	0	0	0	0.2	A
	South Africa	Statistics SA	1.4	2.1	3.4	3	3.1	A
	Togo	MICS3	0	0	0	0	5.9	A
	Uganda	HH surveys	0	0	0	0	0.6	A
	Zambia (2001–02)	DHS	0	0	0	0.1	0	A

Sources: WHO 2011; UNICEF various years for MICS3; World Bank various years for DHS; Bacon, Bhattacharya, and Kojima 2010 for HH (household) surveys; and Statistics South Africa 2008 for Statistics SA. The source for each country is the same as that in Table A1.1 except where the country name is followed by the year of data collection in parentheses.
Notes: Q1 = quintile 1 (bottom, or poorest, quintile), and so on; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MNA = Middle East and North Africa; SSA = Sub-Saharan Africa; + = no distinction made between natural gas and LPG, and hence the answer may apply to either fuel or both; * = total use across fuels greater than 100 percent, indicating that question asked which fuels were used for cooking. Type A indicates use of LPG increases with quintile level; type B indicates that use of LPG decreases with quintile level; type C indicates that use of LPG first increases and then decreases with quintile level.

Table A1.2 in appendix 1 gives usage rates of solid fuels as the primary cooking source by quintile in those countries for which data are available. Although the percentage of households using solid fuels declines at higher quintile levels in all countries, the usage rate even in the top quintile is high in many countries. In one quarter of the 64 countries in the table, more than half of the households in the top quintile rely on solid fuels as the primary cooking source. These statistics further add support to the view that there may be considerable scope for markedly reducing solid fuel consumption.

The relationship between declining use of solid fuels and increasing use of LPG as incomes increase can be seen by considering the correlation between the difference in the rate of LPG use between bottom and top quintiles and the same difference for solid fuel use. Across the set of 51 countries for which LPG use follows pattern A, the correlation between these two differences is –0.65, indicating a strong and widespread tendency for LPG to replace solid fuel as the primary cooking fuel at higher income levels.

4. Statistical analysis of uptake and consumption of LPG

4.1 Study methodology

For modeling LPG selection and use, household expenditure surveys need to be of sufficiently recent date, include separate questions on expenditure on LPG and on the quantity purchased or used, and contain information that enables calculation of prices of competing fuels (from expenditures and quantities), education levels, and other variables found to be statistically significant in this type of demand equation. The surveys should ideally have been conducted within a reasonably similar time period to provide some inter-country comparability, and at fairly recent dates to provide current insights. Taking these considerations into account, this study

takes recent household surveys from Guatemala, India, Indonesia, Kenya, Pakistan, Sri Lanka, Albania, Brazil, Mexico, and Peru. The prices of various fuels paid by each household in the first six countries were calculated by dividing the expenditure on each fuel by the quantity reported in the survey. The remaining four surveys did not report quantity data and national average prices of LPG from other sources were used to back-calculate quantities. The smaller the variation in actual prices paid, the better will be the approximation from using an average price. More details are provided in appendix 2.

Depending on the survey, there are different indicators on whether a household is an LPG user. Every survey reported expenditures on LPG during the sample period. A potential problem in equating positive expenditures on LPG with LPG use is that users who had not refilled their cylinders during the sample period would be treated as non-users.[2] Cross-checking was possible in eight countries in which the surveys asked additional questions related to LPG. These concerned the primary cooking fuel in six countries and other aspects of LPG use in two. Kenya had the largest number of questions specifically targeting LPG. This study takes non-zero response to the question on expenditure on LPG as the indication of LPG use, except where there are discrepancies with data from other questions on LPG, in which case alternative definitions of LPG use are examined (Kenya, Mexico, and Peru).

The approach to modeling fuel selection and fuel use for LPG follows the work of Israel (2002) and uses a Heckman-type model with two equations. The dependent variable is a 1/0 dummy for selection in the first probit (selection) equation and the logarithm of kilograms (kg) of LPG consumed or purchased per month per household in the second (consumption) equation. Heckman's approach allows for the existence of selection bias in the second stage, in which the decision to choose LPG depends in part on unmeasured variables. A maximum likelihood approach is used except in Mexico and Peru, where a two-step estimation procedure is used (see appendix 3) because the number of LPG users in the selection equation is larger than the number of households reporting expenditures on LPG (which yield quantities consumed) in the consumption equation. Analysis for Kenya tests four different definitions of LPG using maximum likelihood or the two-step estimation procedure, depending on the number of user households entered in each stage.

The marginal effect on demand among users is termed the conditional effect, while the sum of this effect and the increased probability of use is termed the unconditional effect. Conditional and unconditional marginal effects are calculated for the first six countries covered in section 4.3 using the maximum likelihood parameter values obtained for the Heckman model.

This study uses household weights to obtain population means. For econometric analysis including Heckman-type models, unweighted estimators would be consistent and more efficient than weighted counterparts unless sample selection is endogenous to the dependent variables being investigated (Deaton 1997; Wooldridge 2002). This study examined both weighted and unweighted estimators and reports the latter except where unweighted estimators produced implausible results: Guatemala where the coefficient for household expenditure was statistically

[2] The need to distinguish the corner solution case (households never use) from random factors leading to non-purchase during the period, even though the household is a regular user, has been discussed in the literature (Deaton and Irish 1984; Blundell and Meghir 1987).

significant and negative in the unweighted estimator but positive in the weighted estimator, and Pakistan where the coefficient for urban residence (which is arguably the closest proxy to availability of natural gas among the available variables) was insignificant for selection if unweighted and significant and negative if weighted.

The selection of variables in the two equations is suggested by other studies of fuel choice (ESMAP 2003a; Gupta and Köhlin 2006; Pundo and Fraser 2006; Mekonnen and Köhlin 2008) and by standard demand analysis. The independent variables investigated in all ten countries— except household-level fuel prices, which were available only in the six countries with quantity data, and a few other items indicated below—are the following:

(1) Total household expenditure. Surveys do not always provide information on income and expenditure is assumed to provide an adequate proxy. Three standard corrections are made to total expenditure, as described below. The coefficient for this variable is expected to be positive in both equations.
(2) Household-level price of LPG (first six countries). That LPG is a homogeneous commodity avoids the well-known problem that households may vary quality when prices change, resulting in the implicit price changes not measuring actual price changes fully. For households that did not buy LPG (and hence did not report expenditure or quantity), the price faced is set equal to the mean of the prices paid by those households reporting positive expenditure. The coefficient is expected to be negative in both equations.
(3) Household-level prices of other fuels (first six countries). The prices of other fuels where available are tested in both equations: kerosene in every country; firewood in every country except Indonesia; charcoal in India, Kenya, and Pakistan; city gas and coal in Indonesia; and the aggregate of coal and charcoal in Guatemala. Again the price faced by non-purchasing households is set equal to the mean price paid by purchasing households. However, if the number of households using a potentially competing fuel is too small, most of the households will be estimated as facing an identical price and this is unlikely to be statistically significant in the Heckman modeling equations. The coefficients in the two equations should be positive.
(4) Number of rooms and house or car ownership. The total expenditure variable is unlikely to capture the economic status of the household fully, especially as auto-consumption of food is included while expenditures on large durables are excluded. All surveys collected information on house and car ownership, and nine out of ten on the number of rooms or floor area (the survey in India did not ask for this information). Those households with more rooms, or who own their own house or cars, may be more asset-rich for a given level of total expenditure. These variables could be positively associated with the decision to use LPG and the amount consumed.
(5) Household size and size squared. At the same household expenditure level, the larger the household, the greater the pressure on other expenditures and less willing the household may be to spend cash on LPG, but the amount consumed by those who have decided to use LPG may increase with increasing household size, although economies of scale in LPG use moderate the rate of increase with size.
(6) Engaging in agriculture. Households engaged in agriculture may have greater access to biomass, and hence less likely to select LPG in the first place or consume less of it. The

coefficient is expected to be negative in the two equations. This information, however, was not available in Brazil.

(7) Education levels. The beneficial effects of using LPG may not be widely known. Fears about potential fires caused by LPG may also be allayed if the consumer feels confident about being able to follow instructions for operating an LPG stove properly. Although none of the survey collected information on these points, the number of years of education may serve as a proxy for access to more information and a better understanding of the issues involved. Because women are usually more closely involved with household fuel use, their education level needs to be viewed separately from that of the men of the household. This study constructed a variable for the highest level of education attained by an adult female member of the household, and an equivalent variable for the highest level of education attained by an adult male member of the household. The hypothesis is that the higher these education levels, the more likely that LPG would be chosen. It is also possible that more LPG would be used with rising level of education. The measurement of the education level varied from survey to survey. In some, coding was more or less proportional to the number of years of education; in others higher codes indicated a higher stage of education (primary, secondary, and so on) but did not provide the number of years of education completed. Details are provided in appendix 4. The coefficients should be positive in both equations.

(8) Head of household. The gender of the head of household—who often controls decisions about expenditures—may play a role in the choice of LPG and the decision on how much to use it. Other things being equal, female-headed households might be more willing to pay for LPG and those using it would purchase more LPG. On the other hand, male-headed households may have more assets and better access to credit and employment, providing them with more cash to pay for LPG. The coefficient for the male head of household may therefore be positive or negative. This study also tests the age of the head of household and whether the household head was an indigenous person. The coefficient for the age of the household head may be positive or negative: positive to the extent that households headed by older members may be more established and have more wealth, and negative if older people view LPG as new and non-traditional and oppose using it. Information on indigenous heads of household was collected in Brazil, Guatemala, Mexico, and Peru. This variable is included on the grounds that many indigenous people live in areas with poor infrastructure, making distribution and marketing of LPG difficult. The coefficient for this variable is expected to be negative.

(9) Urban/rural location. Fuel choice typically differs between urban and rural households. This is in part because of supply differences—rural households may have firewood available to collect but may not have convenient access to LPG supply, while urban households may not have easy access to collected firewood but are more likely to be close to LPG distribution outlets. Accordingly, urban households at the same income level would be expected to be more likely to use LPG. In the consumption equation, a significant and positive coefficient for the urban dummy variable would possibly reflect the reliability of supply or ease of refilling LPG cylinders. One exception is Pakistan, where two-thirds of urban households are connected to natural gas.

(10) Connection to electricity. While the decision to collect firewood or use kerosene and other fuels for cooking is endogenous to the decision to choose LPG and how much LPG to

consume, electricity connection can be considered exogenous. Electricity is rarely used as the primary source of cooking with the exception of Albania, where 40 percent of electricity users reported using electricity to meet some or all of their cooking needs. The availability of electricity for connection is to a large degree exogenous to the household, reflecting public decisions taken by the energy and other ministries. Electricity connection often reflects the state of overall infrastructure (such as all-season roads), higher population density, and other factors that promote the development of an LPG market. The coefficient for electricity connection is expected to be positive in all countries except Albania. In Albania, if electricity was a competing energy source, its coefficient would be negative and should not be retained because it would no longer be exogenous. As seen in section 4.5, the coefficient was positive and was hence retained.

Where coefficients had the wrong sign—more specifically, a positive coefficient for the price of LPG and negative coefficients for the prices of other fuels, negative coefficients for asset indicators (house and car ownership, the number of rooms), a positive coefficient for engaging in agriculture, a negative coefficient for urban residence except in Pakistan, a negative coefficient for electrification except in Albania, and negative coefficients for the two education variables—or were statistically insignificant using a 5-percent significance test, the independent variables were not retained.[3]

As explained in appendix 2, three corrections are made to total expenditure. First, the analysis is based on cash expenditures and the imputed value for food auto-consumption. The latter is included because non-purchased items (auto-consumption), particularly foodstuffs, often provide a large part of the total household consumption in developing countries. Second, where available, deflation factors to account for spatial and temporal differences in prices are used to deflate all food expenditures, both cash and imputed. The deflation factors were not available in India, Indonesia, and Mexico, while only one deflation index differentiating between rural and urban areas was available in Guatemala. Third, infrequent large expenditures, such as vehicle purchase, may unduly inflate total expenditure that is taken as an important determinant of choice and quantity of fuel consumed. To avoid possible distortions arising from such large purchases, expenditures on large durables are excluded in the calculation of total expenditure.

With data drawn from household expenditure surveys, the estimation of selection and consumption equations faces a number of issues that can limit the reliability of the results:

(1) Omitted variables. Arguably the most important variables on which there is no information in the surveys are those related to the conditions of supply of various fuels. The distance to the nearest point of supply for both users and non-users for LPG and for other marketed as well as freely collected fuels, the frequency and duration of supply shortages, and the magnitude of price volatility will all affect the choice and use of LPG. In Pakistan, where natural gas is available for household use in many urban areas, virtually none of the households connected to natural gas used LPG, but no information was available on

[3] In addition, the number of women not working was tested in nine countries that had this information. Increasing number of non-working women might signal more time available to devote to cooking and associated activities including biomass collection, and hence might be expected to be negatively associated with both LPG selection and consumption. In none of the countries, however, was this variable statistically significant and negative.

whether households not using natural gas had the option of being connected. To the extent that these variables are correlated with variables that are included in the equation—for example, better-off households may be closer to LPG outlets—the estimates of their coefficients will be biased. Another item of information not captured by household surveys is the cost of connecting to various forms of energy. For LPG, upfront costs include both the cylinder deposit fee (or cylinder purchase price) and the purchase price of an LPG stove; the connection cost is considerably higher for natural gas.

(2) Missing observations. If there is a pattern to the availability of answers, there can be a bias. Appendix 2 presents information on the sample size at three levels: the total number participating in the survey; the number with complete information on expenditure items, household size, and household weights; and those included in Heckman-style modeling.

(3) Errors of measurement. Aside from recall errors, there are several other sources of errors. In countries without quantity data, the greater the variation in actual prices paid from the national average prices, the larger will be the error. In the countries with quantity data, prices of fuels faced by households cannot be calculated for households that chose not to use a given fuel, and this study uses the average of the prices paid by purchasing households. This approach may be particularly problematic for biomass, for which a commercial market may not exist (dung and agricultural residues) or does not exist in some areas (firewood); even if the fuel is sold, the price may vary greatly from location to location. Finally, the problem of under-estimating the number of user households on account of non-purchase during the survey period was clearly serious in Mexico. The impact of errors of measurement depends on the extent to which the error is correlated with other variables included in the statistical modeling.

(4) Endogeneity. Where there is a feedback from the purchase of LPG to any of the explanatory variables, the latter become endogenous and estimation using the Heckman model would be biased. As with conventional demand systems, income and prices are not expected to be endogenous with respect to the quantities purchased by the household, and other variables, such as those relating to household size, the gender and age of the head of household, and education are also likely to be exogenous. The decision to use another fuel, including collected biomass, would be endogenous and hence cannot be included as independent variables.

In what follows, quintiles are calculated for households ranked by total expenditures per capita and grouped so that each quintile contains the same number of *people*. Urban and rural quintiles are drawn from the nationally based quintile groups so that, for example, the bottom quintile has far more rural people than urban and the share of urban people increases with quintile level.

4.2 Basic statistics by country

The national household surveys in Guatemala, India, Indonesia, Kenya, Pakistan, and Sri Lanka had expenditure and quantity data for LPG as well as a common set of socioeconomic data. Appendix 2 provides brief descriptions of the surveys and how data are handled.

The nature of the LPG market, as well as that for competing fuels, at the time of the survey varied markedly from country to country, particularly with respect to pricing policies.

LPG was heavily subsidized in India and Indonesia. The Indian LPG market for residential consumers largely consisted of subsidized LPG, which was also effectively rationed—there were reportedly 158,000 households on the waiting list for subsidized LPG as of December 2004, mid-point through the survey period (*Business Standard* 2005), although this is a mere 0.3 percent of the total number of households reporting LPG purchase at the time. Market-priced LPG was also available in some areas without any quantitative restrictions, but it was much more expensive and constituted a negligibly small share of the residential LPG market. Kerosene in India and Indonesia was also heavily subsidized at the time. In India, subsidized kerosene has been rationed and distributed through the Public Distribution System according to various criteria, which include the number of cylinders for subsidized LPG belonging to each household and the household's location (state as well as urban or rural) (ESMAP 2003b); households supplemented subsidized kerosene by purchasing market-price kerosene. In Pakistan, natural gas was and continues to be the fuel of choice where it is available, particularly given the government's pricing policy favoring residential customers (World Bank 2003), making LPG the second-best clean-fuel option after natural gas. Statistics on LPG uptake, quantities purchased, and the share of total spending allocated to LPG are provided in appendix 2.

Table 2 provides indications of per capita income, urbanization, and household access to electricity in the six countries. With the exception of per capita expenditure from national accounts, the data are drawn from the household surveys. Access to electricity is shown because it provides an indication of the level of infrastructure development.

Table 2: Average annual per capita expenditure and urbanization in sample countries with data on quantities of fuel consumed

Country	Survey year	Survey sample size	Per capita expenditure from national accounts (2005 $ at PPP)	Per capita expenditure from survey (2005 $ at PPP)	% of HHs in urban areas	% of HHs with positive expenditures on electricity[a]
Guatemala	2006	13,656	3,223	3,777	54	84
India	2004–05	120,427	1,172	704	27	64
Indonesia	2005	9,928	1,943	812	44	88
Kenya	2005–06	12,754	935	1,251	25	15[b]
Pakistan	2004–05	14,700	1,477	861	32	83
Sri Lanka	2006–07	18,473	—	1,673	14	80

Sources: National accounts data and exchange rates from WDI, the rest from national household expenditure surveys and authors' calculations.
Notes: PPP = purchasing power parity; HHs = households; — = not available. All dollar amounts are U.S. dollars.
a. The calculations exclude respondents who were missing data on household size, household weight, or both.
b. The estimate is based on those that reported using electricity in the last month. If the estimate is based on those reporting positive expenditures on electricity, the percentage falls to 8.5.

A supplementary analysis of LPG use was carried out for Albania, Brazil, Mexico, and Peru—for which quantities were not reported in the household expenditure surveys—to see if the findings broadly support those for the first six countries. Table 3 shows the per capita expenditure, urbanization, and access to electricity for these countries. Among the four countries, Mexico has historically subsidized, and continues to subsidize, LPG for residential customers.

Table 3: Average annual per capita expenditure and urbanization in sample countries without data on quantities of fuel consumed

Country	Survey year	Survey sample size	Per capita expenditure from national accounts (2005 $ at PPP)	Per capita expenditure from survey (2005 $ at PPP)	% of HHs in urban areas	% of HHs with positive expenditures on electricity[a]
Albania	2008	3,420	5,799	3,693	53	89[b]
Brazil	2008–09	43,435	5,309	4,566	85	91
Mexico	2008	25,068	8,446	3,163	80	71
Peru	2009	20,414	4,335	3,149	66	83[c]

Sources: National accounts data and exchange rates from WDI, the rest from national household expenditure surveys and authors' calculations.
Notes: PPP = purchasing power parity; HH = households. All dollar amounts are U.S. dollars.
a. The calculations exclude respondents who were missing data on household size, household weight, or both.
b. Although 89 percent of respondents reported positive expenditures, the rate of electrification in Albania is higher.
c. The percentage represents those who replied that they used electricity.

For each of the 10 countries, Table 4 summarizes the percentage of users, quantities purchased per month by user households, and average expenditure shares on LPG by user households. The share of households using LPG was higher in urban areas everywhere except in Pakistan, where many urban households were connected to natural gas. Only in Albania and Brazil had LPG achieved high penetration rates in both rural and urban areas. The amount of LPG purchased or consumed per month by user households tended to be slightly higher for urban households, and generally fell between 9 and 12 kg in urban areas and between 7 and 11 kg in rural areas.

Table 4: Summary statistics on LPG use

Country	Share of households using LPG (%)		Quantity per user household (kg/month)		Expenditure share of user households (%)	
	Rural	Urban	Rural	Urban	Rural	Urban
Guatemala	24	74	11	12	2.7	2.5
India	12	59	9.1	12	4.8	4.3
Indonesia	2.2	13	11	12	3.4	2.3
Kenya	1.2	13	10	9.6	4.5	2.7
Pakistan	8.4	7.0	6.8	11	3.1	4.6
Sri Lanka	21	60	6.7	9.3	1.8	2.3
Albania[a]	71	72	11	12	2.8	3.3
Brazil[a]	81	89	8.0	8.4	3.5	2.5
Mexico[a,b]	54	87	25	30	5.6	4.4
Peru[a]	21	85	7.9	9.6	2.7	2.0

Source: Authors' calculations.
a. Quantities are estimated using national average prices.
b. The shares of households using LPG are based on the statistics for those using LPG as the primary cooking fuel.

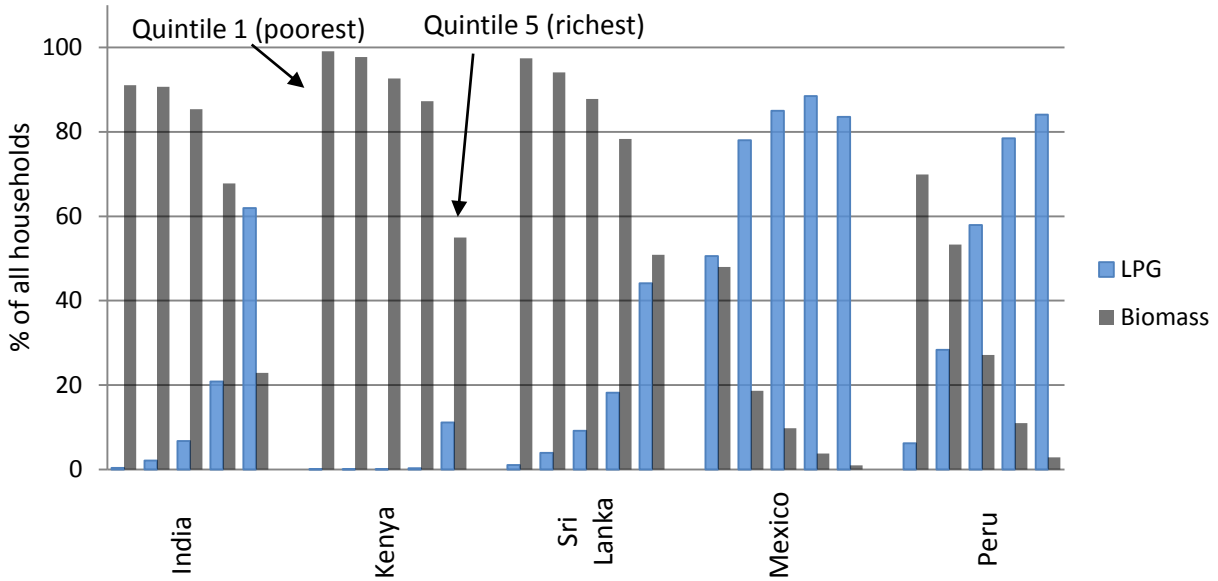
In Mexico, where LPG was also widely used for heating, consumption was much higher than in other countries. The shares of total expenditure allocated to LPG by user households fell mostly in the range of 2.5 to 5 percent. In most cases the share for rural user households was higher than for urban. Pakistan, Sri Lanka, and Albania were exceptions to this pattern, explained

largely by markedly smaller quantities purchased in rural areas. Because total expenditure included imputed expenditure on non-purchased food, the share of total cash expenditure on LPG would be higher.

As shown in appendix 2, the analysis of data by quintile supports the view that the uptake of LPG generally rises with income, as does the amount consumed by users (although less than proportionately); only in Brazil did the estimated quantity of LPG purchased fall at higher quintile levels. The selection rate was greater at higher quintile levels, with the exception of the top urban quintile in Albania, Brazil, Mexico, and Peru where the uptake rate in the fourth quintile was already high or there was competition from electricity or natural gas (Albania and urban Brazil). The differences in the amounts consumed by user households across quintile groups were not large in Guatemala, Indonesia, and Brazil. The expenditure share fell with quintile level except in Pakistan.

Several countries asked each household about its primary cooking fuel, and five countries specified LPG as an option. The results for LPG and biomass are reported for these countries in Figure 3 by expenditure quintile. The share of households using LPG as the primary cooking fuel increased with quintile level except in Mexico, where 13 percent of the top quintile used natural gas. In none of the countries was kerosene used by more than 4 percent of households and electricity by more than 1 percent.

Figure 3: LPG and biomass as the primary cooking fuel



Source: Authors' calculations.

4.3 Econometric analysis using household-level prices

The results for the Heckman estimation using maximum likelihood are provided in Table 5 and the mean values of the independent variables for these estimators in Table 6. The dependent variable in the consumption equation is the logarithm of kilograms of LPG consumed per month per *household*, not per capita, because variation in the quantity purchased was small in Guatemala—the quantity in the 25th percentile was essentially the same as that in the 75th

percentile—and therefore per capita consumption would track mainly changes in household size. Because the dependent variable in the consumption equation is per household and not per capita, total household expenditure as an independent variable is also per household. In Kenya, where six questions related to LPG use were asked, three alternative definitions of LPG users (see appendix 2) were also tested, two of which allowed more LPG-using households to be entered in the selection equation than the 436 households in the model reported in Table 5: (1) households using LPG as their primary or secondary cooking fuel (498 households), (2) households using LPG in the last year (643), and (3) households using LPG cylinders of different sizes in the previous month (414). The third model did not yield a statistically significant positive coefficient for household expenditure in the consumption model. The first two models yielded nearly identical consumption equations to that in Table 5, and similar selection equations but with the appearance of one extra independent variable in the first model and disappearance of one price variable each in both the first and second models; the numerical findings are not reported in this paper.

Table 5: Heckman model for LPG in countries with household-level prices

Independent variable	Guatemala	India	Indonesia	Kenya	Pakistan	Sri Lanka
Selection equation (probit)						
Log of household expenditure	0.54 (0.044)	1.5 (0.016)	1.3 (0.068)	0.78 (0.051)	0.31 (0.042)	1.2 (0.033)
Log of LPG price	—	—	–1.5 (0.27)	–0.76 (0.23)	–2.3 (0.65)	—
Log of firewood price	0.16 (0.030)	0.18 (0.013)	NA	—	—	0.079 (0.031)
Log price of charcoal	NA	—	—	0.27 (0.13)	—	NA
Log of price of kerosene[a]	—	0.88 (0.073)	0.65 (0.15)	—	—	0.25 (0.11)
Number of rooms[b]	—	NA	0.0017 (0.0003)	0.073 (0.021)	0.10 (0.014)	0.098 (0.014)
Dummy for car ownership	—	0.16 (0.037)	0.47 (0.057)	—	—	0.44 (0.061)
Household size	–0.13 (0.012)	–0.31 (0.006)	–0.22 (0.027)	–0.11 (0.016)	—	–0.26 (0.029)
Household size squared	—	0.0066 (0.0003)	0.004 (0.001)	—	—	0.010 (0.003)
Dummy for engaging in agriculture[c]	–0.72 (0.045)	–0.20 (0.016)	–0.18 (0.068)	–0.27 (0.091)	—	–0.59 (0.033)
Highest level of education for men	0.016 (0.008)	0.083 (0.003)	0.026 (0.006)	0.042 (0.011)	0.020 (0.005)	0.065 (0.006)
Highest level of education for women	0.054 (0.007)	0.11 (0.003)	0.041 (0.006)	0.058 (0.012)	0.023 (0.006)	0.078 (0.006)
Age of household head	—	0.002 (0.0005)	—	—	–0.005 (0.001)	
Dummy for male household head	—	—	—	—	—	0.071 (0.036)
Dummy for indigenous household head	–0.57 (0.047)	NA	NA	NA	NA	NA
Dummy for urban residence	0.61 (0.044)	0.48 (0.013)	—	0.22 (0.099)	–0.34 (0.049)	0.64 (0.030)
Dummy for electricity connection	0.87 (0.070)	0.82 (0.020)	0.82 (0.21)	0.59 (0.076)	—	0.85 (0.12)

Independent variable	Guatemala	India	Indonesia	Kenya	Pakistan	Sri Lanka
Constant	–4.68 (0.34)	–16 (0.21)	–12 (2.7)	–7.2 (1.3)	**4.4** **(2.4)**	–16 (0.57)
Consumption equation (regression)						
Log of household expenditure	0.083 (0.016)	0.19 (0.008)	0.23 (0.056)	0.16 (0.078)	0.77 (0.072)	0.26 (0.028)
Log of LPG price	–0.41 (0.12)	–0.96 (0.033)	–0.67 (0.089)	–0.63 (0.11)	–1.3 (0.37)	–0.91 (0.12)
Log of firewood price	0.053 (0.015)	0.12 (0.009)	NA	—	—	0.074 (0.023)
Log of kerosene price[a]	—	0.46 (0.043)	—	—	0.91 (0.28)	—
Log of kerosene price, other[d]	NA	0.073 (0.025)	NA	NA	NA	NA
Dummy for house ownership	0.11 (0.022)	—	—	—	0.19 (0.084)	—
Dummy for car ownership	—	0.035 (0.010)	—	—	0.23 (0.085)	0.064 (0.025)
Household size	—	0.070 (0.003)	0.048 (0.013)	—	–0.036 (0.007)	0.040 (0.006)
Square of household size	—	–0.002 (0.0002)	–0.0008 (0.0002)	—		—
Dummy for engaging in agriculture	–0.067 (0.030)	–0.21 (0.009)	—	—	–0.14 (0.052)	–0.22 (0.025)
Highest level of education for men	—	0.017 (0.002)	—	—	—	0.014 (0.004)
Highest level of education for women	0.011 (0.002)	0.003 (0.001)	—	—	0.051 (0.008)	—
Age of household head	—	0.0004 (0.0002)	—	—	—	0.002 (0.001)
Dummy for male household head	—	0.046 (0.009)	—	—	—	—
Dummy for urban residence	0.073 (0.027)	0.14 (0.007)	—	—	0.26 (0.071)	0.23 (0.020)
Dummy for electricity connection	—	—	—	—	0.18 (0.070)	0.38 (0.14)
Constant	2.4 (0.27)	1.7 (0.17)	4.5 (0.88)	3.6 (0.89)	–4.4 (1.4)	2.2 (0.64)
Inter-equation correlation						
Rho	0.29 (0.068)	–0.17 (0.017)	**–0.12** **(0.11)**	**–0.25** **(0.16)**	0.37 (0.16)	**0.005** **(0.057)**

Source: Authors' calculations

Notes: — = statistically insignificant at 5 percent or of the wrong sign; NA = variable not available in the survey. Coefficients are followed by standard errors in parentheses. Numbers in bold indicate that the variables are not significantly different from zero using a 5-percent test.

a. For India, the price of subsidized and rationed kerosene distributed through the Public Distribution System.

b. Number of bedrooms for Sri Lanka, floor area for Indonesia.

c. This variable is not available in Pakistan and is replaced by an alternative dummy that is 1 if the household owned, leased, or rented agricultural land.

d. Price of unsubsidized kerosene in India.

Table 6: Mean values of the statistically significant variables in the Heckman model

Independent variable	Guatemala	India	Indonesia	Kenya	Pakistan	Sri Lanka
Log of household expenditure	8.2	8.1	14	9.1	8.8	9.9
Log of LPG price	2.1	3.0	8.2	4.8	3.7	4.4
Log of firewood price	–0.74	0.34	—	—	—	1.6
Log of charcoal price	—	—	—	2.3	—	—
Log of kerosene price[a]	—	2.3	7.2	—	3.3	4.1
Log of kerosene price, other[b]	—	2.8	—	—	—	—
Number of rooms	—	—	—	2.3	2.4	2.3
Floor area	—	—	67	—	—	—
Dummy for house ownership	0.76	—	—	—	0.88	—
Dummy for car ownership	—	0.04	0.27	—	0.03	0.06
Household size	5.3	5.2	4.3	5.8	6.9	4.4
Household size squared	—	33	21	—	—	22
Dummy for engaging in agriculture[c]	0.43	0.23	0.46	0.64	0.44	0.31
Highest level of education for men	7.3	4.1	10.3	8.0	6.3	9.3
Highest level of education for women	6.4	3.0	9.3	6.9	3.7	9.4
Age of household head	—	46	45	—	46	50
Dummy for male household head	—	0.93	—	—	—	0.84
Dummy for indigenous household head	0.30	—	—	—	—	—
Dummy for urban residence	0.52	0.36	—	0.30	0.32	0.25
Dummy for electricity connection	0.83	0.74	0.83	0.08	0.82	0.92

Source: Authors' calculations
Note: — = Not applicable.
a. For India, the price of subsidized and rationed kerosene distributed through the Public Distribution System.
b. Price of unsubsidized kerosene in India.
c. This variable is not available in Pakistan and is replaced by an alternative dummy that is 1 if the household owned, released, or rented agricultural land.

The inter-equation correlation coefficient was significant in Guatemala, India, and Pakistan, suggesting the presence of a selection bias. The income effect was statistically significant in every country in both equations. The price of LPG was also significant in every country in the consumption equation but insignificant in the selection equation in half of the countries. As expected, the income effect and the price effect of LPG had by far the two largest effects. Other variables are discussed below:

- **Firewood**. Rising firewood prices increased the chances of LPG selection in Guatemala, India, and Sri Lanka, whereas in Kenya, where firewood use was widespread, prices of charcoal, but not firewood, affected LPG selection. The amount of LPG purchased also increased with rising firewood prices in the first three countries, but charcoal prices were not found to be statistically significant in the consumption equation in Kenya.
- **Kerosene**. Perhaps not surprisingly, the prices of subsidized kerosene in India and Indonesia adversely affected LPG selection. For selection, the coefficient for kerosene prices was also significant in Sri Lanka. For consumption, kerosene prices were significant only in India and Pakistan, and both subsidized and unsubsidized prices were significant in India, although the coefficient for subsidized kerosene was much larger. In

terms of relative magnitude, the price of kerosene in Pakistan had nearly as large an (opposite) effect as the price of LPG.

- **Asset variables**. Car ownership was significant for both selection and consumption in India and Sri Lanka, for selection in Indonesia, and for consumption in Pakistan. The coefficient for selection was large in Indonesia and Sri Lanka, and for consumption in Pakistan. The coefficients for the number of rooms or floor area were significant in the selection equation in four out of five countries where this information was available, but not significant in the consumption equation in any country. House ownership was significant for consumption in Guatemala and Pakistan.
- **Household size**. For selection, the linear term for household size was significant and negative in all countries except Pakistan where it was insignificant. The squared term was significant in three countries. The magnitudes of the coefficients were such that increasing household size had a large negative effect on the probability of using LPG, presumably because of increasing competing demand on the household income for other goods and services. For consumption, the coefficient for the linear term for household size was positive in three countries but negative in Pakistan. The negative coefficient was not rejected because it is possible that the same pressure on household income with increasing household size could be exerting downward pressure on LPG purchase. A positive coefficient would mean that more cooking energy is needed for larger families, although the largest coefficient was 0.07, suggesting significant economies of scale.
- **Engagement in agriculture**. This is the only variable in the model that is related to the availability of biomass. For selection, the coefficient for this variable was significant and negative in all countries except Pakistan where it was insignificant, and was large in Guatemala and Sri Lanka. It was also significant and negative in the consumption equation in all countries except Indonesia and Kenya, and was comparable in magnitude in India, Pakistan, and Sri Lanka.
- **Education**. The highest levels of education attained by men and women were statistically significant in the selection equation in every country, and the coefficient was larger for women than for men in each case. The education variables were not as important in the consumption equation, with both variables being statistically significant only in India; elsewhere, only women's education in Guatemala and Pakistan, and only men's in Sri Lanka, seemed to matter. Men's education appeared to influence the amount consumed more than women's in India and Sri Lanka. One possible explanation is that men influence decisions on cash expenditures more than women and having well-informed male members of households makes it easier to purchase more LPG.
- **Household head**. For selection, the age of the head of household was significant only in India and Pakistan and their respective coefficients were opposite in sign. For consumption, this variable was significant and positive in India and Sri Lanka. One possible explanation is that the age of the head of household is capturing some aspects of wealth, and that this compensates for any resistance that older heads of household may have to using LPG, a non-traditional fuel. The gender of the head of household was significant only in Sri Lanka for selection and in India for consumption; the coefficient was positive in both cases. As with the age of the head of household, these findings may suggest that, although men may be less willing to pay for LPG for its convenience and clean burning characteristics, at the same expenditure level, households headed by men

tend to have more assets as well as access to finance, making more cash available. As Table 6 shows, the percentage of female-headed households was small, particularly in India. Guatemala was the only country that had data on whether the head of household was indigenous. The coefficient was significant, large, and negative for selection, and insignificant for consumption.

- **Urban residence**. Urban residence increased the probability of selecting LPG in four countries and decreased it in Pakistan (where two-thirds of urban residents were connected to natural gas). Once having selected LPG, however, urban households in Pakistan consumed more LPG than their rural counterparts, reversing the sign of the coefficient in the consumption equation. The coefficients were comparable in magnitude in Guatemala, India, and Sri Lanka for selection and in India, Pakistan, and Sri Lanka for consumption.
- **Electricity connection**. Access to electricity increased the probability of selection in all countries except Pakistan (possibly because electrification is closely linked to urban residence), and the coefficients were large and close in magnitude. This variable was significant only in Pakistan and Sri Lanka in the consumption equation. One possible interpretation is that electrification connection is indeed a good proxy for having adequate infrastructure for LPG distribution and that households with electricity have better access to LPG. It is also possible that electrification serves as another asset indicator and that households with electricity have greater cash income.

Table 7 summarizes the marginal effects calculated from the estimations presented in Table 5. The differences between the conditional and unconditional effects were large in some cases, for example for income elasticity in Guatemala, India, and Sri Lanka. Focusing on unconditional marginal effects, which combine three effects as explained in appendix 3, income elasticities varied between 0.3 and 0.7. Own price elasticities were close to 1 in India, Pakistan, and Sri Lanka. The price elasticity for kerosene was high in India and Pakistan, and that for subsidized kerosene was an order of magnitude larger than that for market-priced kerosene in India. Household size generally had a negative effect on LPG consumption.

Table 7: Conditional and unconditional marginal effects

Independent variable	Guatemala	India	Indonesia	Kenya	Pakistan	Sri Lanka
Conditional marginal effect						
Log of household expenditure	0.044	0.28	0.29	0.27	0.70	0.26
Log of LPG price	–0.41	–0.96	–0.74	–0.74	–0.75	–0.91
Log of firewood price	0.042	0.13	—	—	—	0.074
Log of charcoal price	—	—	—	0.040	—	—
Log of kerosene price[a]	—	0.51	0.033	—	0.91	–0.001
Log of kerosene price, other[b]	—	0.073	—	—	—	—
Number of rooms[c]	—	—	0.00008	0.011	–0.023	–0.0002
Dummy for house ownership	0.11	—	—	—	0.19	—
Dummy for car ownership	—	0.044	0.023	—	0.23	0.063
Household size	0.009	0.053	0.038	–0.016	–0.036	0.041
Household size squared	—	–0.002	–0.001	—	—	–0.00002

Independent variable	Guatemala	India	Indonesia	Kenya	Pakistan	Sri Lanka
Dummy for engaging in agriculture[d]	–0.014	–0.22	–0.010	–0.039	–0.14	–0.22
Highest level of education for men	–0.001	0.021	0.001	0.006	–0.005	0.014
Highest level of education for women	0.007	0.009	0.002	0.009	0.046	–0.0002
Age of household head	—	0.001	0.0002	—	0.001	0.002
Dummy for male household head	—	0.046	—	—	—	–0.0002
Dummy for indigenous household head	0.043	—	—	—	—	—
Dummy for urban residence	0.029	0.17	—	0.033	0.33	0.23
Dummy for electricity connection	–0.069	0.048	0.040	0.086	0.18	0.38
Unconditional marginal effect						
Log of household expenditure	0.26	0.74	0.32	0.28	0.73	0.59
Log of LPG price	–0.41	–0.96	–0.79	–0.75	–1.0	–0.91
Log of firewood price	0.11	0.18	—	—	—	0.095
Log of charcoal price	—	—	—	0.042	—	—
Log of kerosene price[a]	—	0.77	0.053	—	0.91	0.065
Log of kerosene price, other[b]	—	0.073	—	—	—	—
Number of rooms[c]	—	—	0.0001	0.001	–0.010	0.026
Dummy for house ownership	0.11	—	—	—	0.19	—
Dummy for car ownership	—	0.094	0.042	—	0.23	0.20
Household size	–0.042	–0.038	0.031	–0.017	–0.036	–0.029
Household size squared	—	0.000	–0.001	—	—	0.003
Dummy for engaging in agriculture[d]	–0.29	–0.28	–0.016	–0.042	–0.14	–0.36
Highest level of education for men	0.005	0.046	0.002	0.006	–0.002	0.031
Highest level of education for women	0.028	0.042	0.003	0.009	0.048	0.021
Age of household head	—	0.001	0.0004	—	0.001	0.002
Dummy for male household head	—	0.046	—	—	—	0.018
Dummy for indigenous household head	–0.18	—	—	—	—	—
Dummy for urban residence	0.27	0.32	—	0.035	0.30	0.42
Dummy for electricity connection	0.25	0.25	0.055	0.096	0.18	0.54

Source: Authors' calculations
Note: — = coefficient not significant in either equation.
a. For India, the price of subsidized and rationed kerosene distributed through the Public Distribution System.
b. Price of unsubsidized kerosene in India.
c. Number of bedrooms for Sri Lanka, floor area for Indonesia.
d. This variable is not available in Pakistan and is replaced by an alternative dummy that is 1 if the household owned, released, or rented agricultural land.

In certain cases variables are significant in the selection equation but not in the consumption equation. The conditional and unconditional marginal effects on consumption depend not only on the sign of the coefficient in the selection equation but also on the sign of the inter-equation error correlation (rho). As noted in appendix 3, a positive rho can reverse the sign of the variable identified in the selection equation in the calculation of the conditional marginal effect. The number of rooms and the highest level of male education in Pakistan yielded positive coefficients in the selection equation, but their conditional and unconditional effects, determined in part by the positive values of rho, are negative—the correlation of the variable omitted from

both equations with the variable included in the selection equation makes the total effect of that variable appear negative. Similarly, the conditional marginal effects for the highest level of men's education, the dummy for an indigenous head of household, and the dummy for electricity connection in Guatemala; and the price of kerosene, the number of bedrooms, and the highest level of education for women in Sri Lanka arise solely from indirect effects through the value of rho and have the opposite sign to what would have been expected for the directly obtained coefficient.

4.4 Econometric analysis using national average prices

Analysis using surveys without quantitative information on fuel use is limiting, but to the extent that it reproduces the findings in section 4.3, such analysis can strengthen the conclusions drawn. The numbers in this section need to be treated with care, because they are subject to an even greater possibility of being biased on account of additional omitted variables.

The same independent variables, barring household-level fuel prices, are examined in the four countries without quantity information. Because household-level prices are not available, conditional and unconditional marginal effects are not calculated for these countries. Brazil is treated differently because, at 89 percent, LPG use in urban areas in Brazil is already high, and the share rises to 92 percent if natural gas users are added. Virtually all of the remaining 8 percent of households had electricity connection, many of whom could have been using electricity for cooking. Therefore, the two-stage Heckman estimation in Brazil focuses only on rural households, while a regression equation is tested for consumption for urban households entering only user households. The results are summarized in Table 8.

Table 8: Heckman model in countries with national average prices

Independent variable	Albania	Brazil rural	Brazil urban	Mexico	Peru
Selection equation (probit)					
Log of household expenditure	0.37 (0.055)	0.35 (0.025)		0.24 (0.014)	0.69 (0.028)
Number of rooms[a]	0.12 (0.027)	0.040 (0.010)		0.021 (0.011)	0.017 (0.008)
Household size	0.14 (0.046)	–0.088 (0.010)		0.11 (0.008)	–0.16 (0.007)
Household size squared	–0.015 (0.004)	—		–0.004 (0.0006)	—
Dummy for engaging in agriculture	—	UA		–0.32 (0.031)	–0.52 (0.035)
Highest level of education for men	—	0.031 (0.005)		—	0.020 (0.003)
Highest level of education for women	—	0.029 (0.005)		—	0.036 (0.003)
Age of household head	–0.005 (0.002)	—		0.005 (0.0006)	—
Dummy for male household head	0.64 (0.085)	—		—	0.15 (0.035)
Dummy for indigenous household head	UA	–0.33 (0.14)		–0.63 (0.029)	—
Dummy for urban residence	0.46 (0.050)	NA		0.17 (0.023)	0.69 (0.035)

Independent variable	Albania	Brazil rural	Brazil urban	Mexico	Peru
Dummy for electricity connection	0.55 (0.079)	—		—	0.74 (0.042)
Constant	–6.0 (0.69)	–1.4 (0.16)		–2.5 (0.12)	–5.5 (0.17)
Consumption equation (regression)					
Log of household expenditure	0.18 (0.033)	0.080 (0.015)	0.030 (0.004)	0.51 (0.037)	0.098 (0.011)
Number of rooms[a]	0.073 (0.014)	—	0.018 (0.001)	0.090 (0.006)	0.008 (0.003)
Dummy for house ownership	—	—	0.034 (0.007)	—	—
Dummy for car ownership	0.097 (0.034)	0.039 (0.014)	—	—	—
Dummy for engaging in agriculture	–0.089 (0.029)	NA	NA	–0.33 (0.057)	–0.059 (0.014)
Household size	—	0.099 (0.012)	0.20 (0.005)	0.10 (0.019)	0.097 (0.009)
Household size squared	—	–0.006 (0.001)	–0.012 (0.001)	–0.005 (0.0009)	–0.004 (0.0007)
Highest level of education for men	0.006 (0.003)	—	—	0.002 (0.001)	—
Highest level of education for women	—	—	—	0.003 (0.001)	—
Age of household head	—	0.002 (0.0004)	0.005 (0.0002)	0.010 (0.0008)	0.003 (0.0003)
Dummy for male household head	—	—	0.018 (0.006)	—	—
Dummy for indigenous household head	UA	–0.13 (0.061)	—	–0.79 (0.11)	—
Dummy for urban residence	—	NA	NA	0.16 (0.030)	0.040 (0.018)
Dummy for electricity connection	—	—	0.052 (0.011)	—	—
Constant	**–0.33 (0.45)**	1.2 (0.12)	0.89 (0.027)	–3.6 (0.62)	0.98 (0.091)
Inter-equation correlation					
Rho/Inverse Mills ratio[b]	**–0.085 (0.18)**	–0.22 (0.084)	NA	1.8 (0.28)	–0.33 (0.056)

Source: Authors' calculations

Notes: — = statistically insignificant or of the wrong sign; NA = not applicable; UA = data for the variable unavailable in the survey. Numbers in bold indicate that the variables are not significantly different from zero using a 5-percent test.

a. Number of bedrooms for Mexico, floor area for Albania.

b. Rho in Albania and Peru, inverse Mills' ratio in Brazil rural and Mexico.

As with the first six countries, the coefficient for household expenditure was significant in every equation. The elasticities in the consumption equation fell within a comparable range to that in Table 5. The number of rooms was significant for selection in every case, and was also significant for consumption except for rural Brazil. House or car ownership was insignificant for selection but significant for consumption in Albania and Brazil. Where the coefficient for household size was significant in the consumption equation, they were all positive and larger than in Table 5. For selection, household size had a parabolic shape in Albania and Mexico with a positive sign for the linear term, resulting in increasing probability of selection up to a certain

household size (5 in Albania and 13 in Mexico). While there is no compelling reason to reject such a relationship *a priori*, neither is there an obvious explanation for such a trend. Agricultural engagement decreased the probability of using LPG in Mexico and Peru and the quantity of LPG purchased in Albania, Mexico, and Peru, with comparable magnitudes in the two equations to those in Table 5.

The highest levels of education were significant for both men and women only in rural Brazil and Peru (selection) and in Mexico (consumption). The coefficients were comparable in magnitude in rural Brazil and larger for women in Peru and Mexico. In addition, rising men's education, but not women's, increased the quantity of LPG consumed in Albania. The age of the head of household was significant for selection in Albania and Mexico, and their respective coefficients had the same magnitude but were opposite in sign. For consumption, the age of the household head was significant and positive in all cases except Albania where it was insignificant. The gender of the head of household mattered for selection in Albania and Peru, and for consumption in urban Brazil, with a positive coefficient in all three cases. Having an indigenous head of household decreased the probability of LPG use as well as the quantity purchased in rural Brazil and Mexico; in the selection equation, the coefficients in rural Brazil and Mexico were comparable in magnitude to that in Guatemala. In the three cases where urban residence was a relevant variable, it was significant for selection in every case and for consumption in two out of three cases. Electricity connection was significant and positive only in Albania and Peru in the selection equation and in urban Brazil in the consumption equation. The magnitudes of the coefficients in Albania and Peru were comparable to those in Table 5.

Comparison across 10 countries shows that many of the results in Table 8 corroborate those in Table 5. The magnitudes of the coefficients for household expenditures and agricultural engagement are broadly comparable between the two tables for both selection and consumption; those for education, the age of the head of household, indigenous head of household, and electricity connection are comparable for selection; and those for car ownership and urban residence are comparable for consumption.

One variable that was expected to be significant and negative, based on findings in other studies (Mekonnen and Köhlin 2008; Farsi, Filippini, and Pachauri 2005), is the dummy for a male head of household. The findings across the 10 countries, however, do not support the view that having a female head of household would promote a shift to clean commercial fuels. In the six countries with quantitative data, the gender of the head of household was significant in two cases and the sign was positive for both. In the four countries without quantity data, the gender variable was significant in three equations, and the sign was again positive in each case. These results do not necessarily suggest that female heads of household are less willing to switch to LPG. As mentioned earlier, female-headed households may suffer from economic disadvantages—such as having greater difficulties accessing credit or not having title to land—thereby constraining their ability to spend cash at the same total household spending as defined in this study and hence being less able to purchase LPG.

5. Reflections on increasing the use of LPG

For households for whom LPG is the cleanest form of household energy (that is, households who do not have access to natural gas and who would not consider electricity for cooking and heating), affordability is the most important determinant of LPG. The findings of this study enable one measure of affordability to be constructed: the percentage of total household spending needed to purchase 1 kg of LPG. Table 9 compares national selection rates and quantities consumed in the light of that measure of affordability. The table also compares three prices: local retail prices in U.S. dollars, the average of residential LPG prices during the survey period in the United States, and the average of free-on-board (FOB) prices of LPG during the survey period. Comparison of retail prices is not straightforward because transport costs vary from country to country as do taxes and subsidies. Although U.S. retail prices serve as suitable reference points particularly for Guatemala, Brazil, Mexico, and Peru, they are shown for all countries because the U.S. LPG market has no subsidies or price control and is characterized by large economies of scale and high efficiency. FOB prices are taken from a geographically relevant market for each country and represent prices before the costs of transport, bottling, distribution, and retailing as well as taxes are added.

Table 9: Affordability of LPG

Country	Share of households using LPG (%)	Quantity per user household (kg/month)	Retail price of LPG (US$/kg) Local[a]	USA[b]	FOB price of LPG (US$/kg)	1 kg of LPG/total household expenditure (%)
Guatemala	51	12	1.11	0.78	0.47	0.2
India	24	11	0.47	0.62	0.39	0.6
Indonesia	7.1	12	0.41	0.65	0.39	0.4
Kenya	4.0	9.7	1.63	0.72	0.48	1.0
Pakistan	7.9	8.1	0.71	0.62	0.39	0.5
Sri Lanka	26	7.6	0.75	0.79	0.52	0.4
Albania[c]	71	12	1.51	1.08	0.88	0.2
Brazil[c]	88	8.4	1.39	0.99	0.53	0.2
Mexico[c,d]	80	29	0.86	1.07	0.69	0.1
Peru[c]	63	9.4	1.08	0.78	0.36	0.2

Source: U.S. EIA (2011) for U.S. prices, Reuters for FOB prices in the North Sea and Saudi Aramco contract prices, and authors' calculations.

Notes: FOB = free on board. FOB prices are taken from Mont Belvieu propane prices in Texas, United States for Guatemala, Brazil, Mexico and Peru; the average of propane and butane prices from the North Sea for Albania; and the average of propane and butane Saudi Aramco contract prices for India, Indonesia, Kenya, Pakistan, and Sri Lanka.

a. Local retail prices of LPG converted to U.S. dollars using the market exchange rate at the time of the survey.

b. National average retail prices of LPG for residential consumers in the United States at the time of the survey.

c. Quantities are estimated using national average prices.

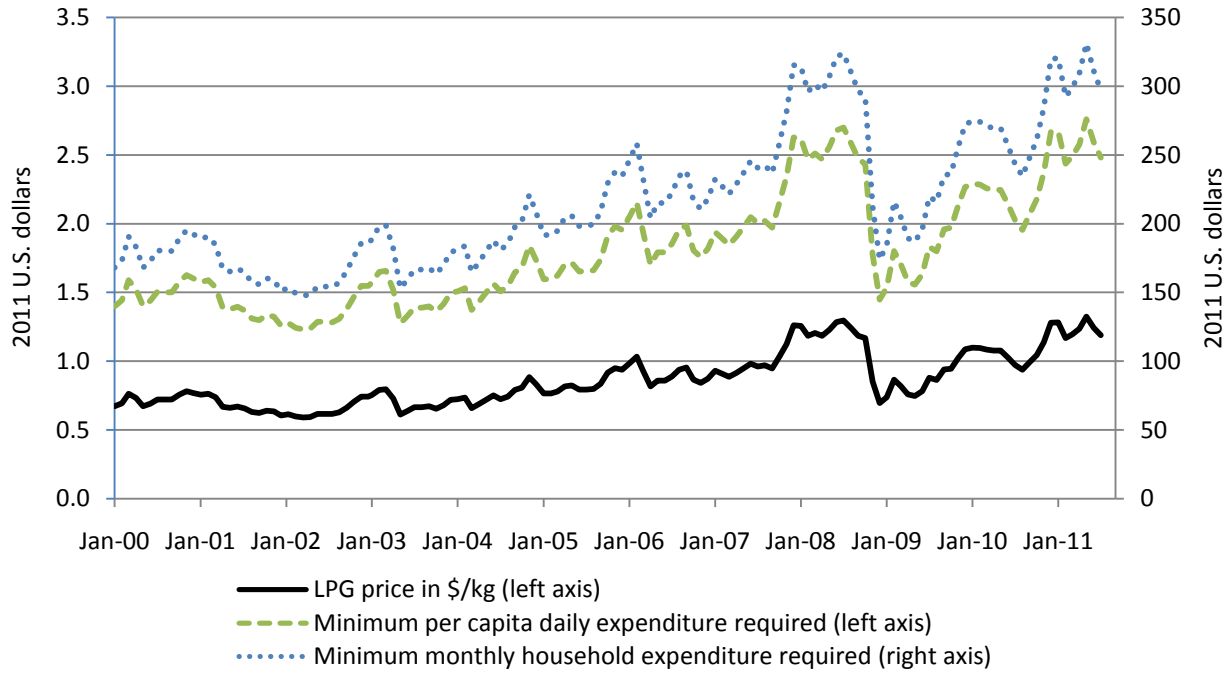
d. The shares of households using LPG are based on the statistics for those using LPG as the primary cooking fuel.

Comparison of local and international prices provides clear evidence of price subsidies in India, Indonesia, and Mexico. The combination of subsidies and relatively high income made LPG most "affordable" in Mexico, although a greater share of households was using LPG in Brazil. What the low ratio of price to income seemed to increase in Mexico was the average quantity purchased, which was nearly triple the average of the remaining nine countries. The

affordability of LPG in Guatemala, Albania, Brazil, and Peru was comparable, but the selection rate ranged from 51 percent to 88 percent. These differences may be for a variety of reasons, including the share of unpurchased food in total household expenditure, the importance of excluded expenditures (large durable goods), differences in household income (in contrast to measured expenditures), supply conditions of LPG and other fuels, upfront costs of LPG use, and cultural acceptance of different fuels. Nevertheless, the differences in the selection rate among countries with comparable affordability of LPG suggest that there is potential to increase its use further and help reduce reliance on solid fuels with their attendant problems.

Given that income and LPG prices are crucial determinants of LPG selection and consumption and that international prices of LPG have seen far greater volatility than household income in recent years, it is informative to examine recent price trends. Figure 4 provides estimates of minimum income levels needed to use LPG regularly for cooking, expressed in 2011 U.S. dollars. Although based on historical LPG prices, the calculations use a number of simplifying assumptions, resulting in large uncertainties. As such, the estimates should be seen as being indicative. One assumption is that LPG's share of household spending is 4 percent, which is near the upper end of the range observed in Table 4. The calculations show that total household expenditure of between US$150 and US$200 would have enabled regular use of LPG up to 2005, but with recent price rises on the international market, households would need to be earning nearly double that today, more than US$300 a month, to purchase 10 kg of LPG per month while limiting the expenditure to 4 percent of total household spending. Because these calculations do not take expenditures on large durable goods or the start-up costs of LPG into account, household income would likely need to be even higher.

Figure 4: World LPG price and daily per capita and monthly household expenditure needed for regular use of LPG



Sources: Reuters for Saudi Aramco contract prices for propane and butane and authors' calculations.
Notes: LPG is assumed to be an equal mixture of propane and butane. Calculations assume transportation, bottling, distribution, and retailing costs and taxes totaling $350 a tonne of propane in 2011 U.S. dollars; monthly

consumption of 10 kg per household with four members; and 4 percent of total monthly household expenditure spent on LPG.

A doubling of income in a decade would require an annual growth rate of 7 percent in real terms. At the national level, very few countries have achieved such robust growth in household income. There are individual households within each country that have achieved an increase in income of this magnitude, and they are more likely to be urban than rural. That said, there are situations where retail prices could be markedly lower than those shown in the figure. If there is no easy way of exporting LPG, export-parity prices and hence the market-clearing prices of LPG could be considerably lower than world prices (provided that net-of-tax prices are adequate for full cost recovery and a reasonable profit margin), making the minimum monthly income needed for regular use of LPG correspondingly lower than in Figure 4. There are also regional differences. The U.S. retail prices were higher than those in the figure between November 2008 and April 2009, but have been lower since, for example by about 20 percent in 2010.

To promote access to modern energy services, some governments have been providing price subsidies for LPG for household use. These subsidies tend to be universal and hence regressive (World Bank 2010a, table 6). Recent run-ups in world prices have led to mounting burdens on government finance (Kojima 2009). If such financial assistance is to be provided, capital subsidies (subsidies for start-up costs) are generally acknowledged to be better than operating-cost subsidies (such as fuel or power tariff subsidies), but only if the consumers can pay for the operating costs themselves so that a viable energy market can develop. In this regard, there are important differences between electricity and fuels. For electricity, the initial connection cost is orders of magnitude higher than monthly operating costs. At the same time, those without electricity are typically already paying cash for much inferior alternatives—such as kerosene for lighting or batteries—and that cash can be redirected to pay partially or fully for electricity. For LPG, the difference between the initial start-up cost (US$40–60 for a stove and the cylinder deposit) and the operating cost paid for cylinder refills (US$12 a month at today's prices in the above illustrative example) is considerably smaller, while the operating costs themselves are sufficiently high to present a barrier to regular use of LPG by low-income families. Further, many among low-income families may be paying no cash for cooking and heating fuels and hence have no cash to redirect toward LPG purchase. Under these circumstances, it is not clear that capital subsidies would be pro-poor. It may be argued that households who can reasonably afford the LPG refill cost of US$10–15 a month are capable of paying US$40 to start the service; it may also be argued that, for these households, other financial arrangements, such as recovery of start-up costs through the cost of refill, may be more appropriate.

Targeted capital-subsidy schemes for fuel use are rare but there have been such schemes in developing countries. For example, the state government of Andhra Pradesh in India in 1999 launched the Deepam Scheme to promote the use of LPG by the poor to reduce the drudgery of biomass collection and cooking, improve health, and slow deforestation. Under the scheme, the government covered the cylinder connection fee for starting LPG service to those families classified as being below the poverty line. An assessment of the Deepam Scheme completed by the World Bank in 2002 found that the scheme clearly facilitated the uptake of LPG by the rural poor. However, biomass remained the main cooking fuel for the majority of Deepam

beneficiaries, especially cash-strapped rural households who could not afford the relatively high operating cost of the LPG service, even though LPG itself was heavily subsidized at the time. The high costs of cylinder refills confined LPG largely to incidental use, such as making tea or preparing meals for unexpected guests, or to when the opportunity cost of firewood use was substantial, such as during the monsoon season. The average consumption level of LPG was 2.9 kg per month, against a minimum of 7 kg considered to be necessary to meet the majority of cooking needs. LPG use also tended to increase where there was home delivery of LPG, suggesting that arranging for cylinder delivery by a household, even if it does not cost in monetary terms, discourages consumption of LPG (Rajakutty and others 2002). Although even limited use of LPG improves household welfare and particularly of women charged with cooking, this consumption pattern limits the health and other social benefits of LPG uptake, as well as the potential for commercially viable LPG businesses.

Taken together, these findings suggest that government incentive schemes for household use of LPG to substitute biomass are likely to be more effective if they focus on areas where biomass is diminishing, the costs of biomass cooking are high, and there is infrastructure for reliable LPG delivery which does not impose an undue burden on households. The last aspect would include the existence of a tarred road connecting the nearest bottling plant to a shop selling LPG and inexpensive means of getting to the shop by consumers or home delivery at a nominal fee, if any.

One avenue for LPG promotion that does not involve a large outlay of subsidies and that is supported by the findings of this study is raising awareness about the costs and benefits of LPG use. The econometric analysis in this study suggests that a household's willingness to start using LPG increases with education level, particularly of women. It has been argued that households do not choose to use LPG because women (who would otherwise wish to use it) do not control financial decisions and men as heads of household do. Increasing the levels of education of both men and women could go a long way to improving the chances of LPG selection, and women's education seems to influence fuel choice perhaps even more than men's. For the purpose of persuading households to start using LPG, education is likely to be a proxy for the level of awareness about the benefits and costs of LPG. One possible conclusion is that awareness-raising and basic training about safety features of LPG might be effective in shifting households away from solid fuels to LPG.

Starting to use LPG is not the same as abandoning solid fuels and shifting entirely to clean-burning fuels, as the experience with the Deepam Scheme amply demonstrates. But starting to use LPG is the first step, and, with experience, a household will feel increasingly comfortable handling LPG. The importance of the latter was demonstrated by the comments made in a recent consultation meeting on energy issues with a community outside of Lomé in Togo. There was almost no knowledge of LPG among the women present, and those few who had heard about LPG described it as a very dangerous fuel capable of burning down houses. The women also said that LPG would be out of their reach, although they had no idea of its cost (World Bank 2010b). Awareness-raising could help those who are financially able to start using LPG. Increasing use of LPG in the community could in turn lead others to consider LPG through demonstration effects.

In promoting household use of LPG, it would make sense to target households whose income is sufficiently high to start using LPG without subsidies and who already live in areas with LPG marketers, because these households are most likely to be in a position to switch entirely to LPG and sustain its use. Such a shift will also help ease growing pressure on biomass resources, which will continue to be used by the poor for the foresseable future and the mitigation policy for which must involve not only fuel switching but also cleaner-burning, efficient stoves for solid fuels (UNDP and WHO 2009; IEA 2010).

The government can contribute in a variety of ways to facilitate household use of LPG within and outside the LPG sector.

- Within the LPG sector, the government can strengthen its regulation-setting and enforcement role. Short-weighting can be all too prevalent—in the extreme, substances other than LPG, such as water, have been known to be added to cylinders to increase the weight and give the appearance of selling the correct amount of LPG. Lowering supply costs by not inspecting and repairing cylinders regularly and instead allowing unsafe cylinders to circulate is another potential problem, posing a threat to public safety and entrenching the reputation of LPG as a "dangerous fuel capable of burning down houses." Without effective regulation, a competitive market with a large number of marketers is likely to lead to partial or total degradation of product quality. A low-quality product (LPG in unsafe cylinders, LPG cylinders filled in part with substances other than LPG) drives out a high-quality product because of consumers' difficulty in distinguishing between the two—especially if there is no effective monitoring and enforcement. Even if prices initially are kept at a level that would cover the costs of the high-quality product, the excess profits that unscrupulous firms can gain by selling inferior products could encourage them to cut prices in order to increase sales. Eventually prices could drop until they cover only the costs of inferior products. In a well-regulated market, suppliers that run efficient operations while complying with safety and other standards might be able to expand their market shares and drive out unscrupulous firms.
- Outside the LPG sector, provision of roads on which heavy trucks can travel is the first requirement for being able to deliver LPG cylinders in sufficient quantities. Other requirements include port facilities capable of handling LPG imports in countries where domestic supplies are inadequate to meet demand.

LPG marketing companies can also contribute by devising schemes to enable the start-up costs to be spread over time, experimenting with different-size cylinders to match consumers' cash flow patterns, and considering different logistical options for lowering costs of supply to consumers outside of concentrated urban settings. Consumers who are well educated about the benefits and costs of LPG—ease of use, health benefits, safety features concerning use and the conditions of cylinders, and awareness about short-weighting—are also important for the development of a sustainable and vibrant LPG market. Governments, LPG marketing companies, and civil society organizations can all contribute to consumer education and awareness-raising in this regard.

Appendix 1: Use of LPG and Solid Fuels for Cooking by Country

Table A1.1: LPG and solid fuels as primary cooking fuel in developing countries

Region	Country	Source	Year	% all house-holds using LPG	% urban house-holds using LPG	% rural house-holds using LPG	% using solid fuels
Asia	Afghanistan	WHO	2007	10	50	3	86
	Bangladesh	WHO	2007	0.8	3	0.2	91
	Bhutan	MICS related	2007	23	45	13	42
	Cambodia	HH surveys	2003–04	5.1	23	2.1	93
	China	WHO	2006	28	40	22	49
	India	HH surveys	2004–05	22	60	8.6	70
	Indonesia+	WHO	2007	11	20	3.8	43
	Lao PDR	MICS3	2006	0.8	2.5	0.1	98
	Malaysia	WHO	2003	96	96	95	0.8
	Mongolia	MICS3	2005	23	0.6	0	77
	Nepal	WHO	2006	10	40	3.9	83
	Philippines	WHO	2003	48	62	27	45
	Solomon Islands	WHO	2007	7.7	41	2.5	92
	Sri Lanka	This study	2006–07	17	51	12	80
	Thailand	MICS3	2005–06	59	81	51	37
	Tonga	WHO	2006	54	84	45	41
	Vanuatu	MICS3	2007	12	44	2.6	85
	Vietnam	MICS3	2006	31	70	18	66
ECA	Albania	MICS3	2005	33	50	19	56
	Armenia	WHO	2005	37	40	31	4
	Azerbaijan+	WHO	2006	69	84	48	10
	Belarus	MICS3	2005	26	9.2	57	3.4
	Bosnia and Herzegovina	MICS3	2006	5.5	9.4	3.2	49
	Croatia	WHO	2003	75	78	68	12
	Estonia	WHO	2003	38	43	24	16
	Georgia	MICS3	2005	12	18	5.4	54
	Kazakhstan	MICS3	2006	40	37	47	19
	Kyrgyz Republic	MICS3	2006	9	9.3	8.7	37
	Latvia	WHO	2003	82	88	67	9.8
	Macedonia, FYR	MICS3	2005	2.5	3.8	0.5	36
	Montenegro	MICS3	2005	2.0	2.1	1.8	32
	Russian Federation	WHO	2005	26	9.2	59	3.4
	Serbia	MICS3	2005	8.6	9.2	7.6	34
	Slovak Republic	WHO	2003	80	84	74	2.9
	Tajikistan	MICS3	2005	4.5	11	1.6	35
	Turkmenistan+	DHS	2000	96	—	—	0.3
	Ukraine	MICS3	2005	8.1	3.4	19	9.1
	Uzbekistan	MICS3	2006	2.2	3	2.6	16
LAC	Antigua Barbuda	WHO	2007	96	—	—	2

Region	Country	Source	Year	% all house-holds using LPG	% urban house-holds using LPG	% rural house-holds using LPG	% using solid fuels
	Belize	MICS3	2006	82	92	69	14
	Bolivia	WHO	2007	68	89	29	29
	Brazil	WHO	2003	87	95	47	13
	Colombia	WHO	2005	37	37	37	15
	Dominican Republic	MICS related	2006	80	89	64	13
	Ecuador	WHO	2006	91	99	76	8.6
	El Salvador	WHO	2007	73	86	46	22
	Guatemala	WHO	2003	37	68	14	62
	Guyana	MICS3	2006	48	61	42	10
	Haiti	WHO	2005	2.1	4.6	0.6	94
	Honduras	WHO	2005	20	33	6.7	52
	Jamaica	WHO	2001	80	—	—	16
	Mexico	This study	2008	79	86	51	13
	Nicaragua	WHO	2006	41	66	7.3	57
	Paraguay	WHO	2007	50	68	22	48
	Peru	This study	2009	55	78	11	32
	Suriname	MICS3	2006	83	89	42	15
	Trinidad and Tobago	MICS3	2006	93	—	—	0.3
	Uruguay	WHO	2003	94	94	90	0.8
MNA	Algeria	WHO	2006	60	39	89	1.2
	Djibouti	MICS3	2006	4.9	5.1	0.6	13
	Egypt, Arab Rep.	WHO	2005	85	76	93	0.3
	Eritrea	WHO	2002	4.7	4.8	0.2	66
	Iraq	MICS3	2006	86	92	74	4.6
	Jordan	WHO	2002	99.5	99.6	99.2	0.08
	Morocco*	DHS	2003–04	100	—	—	9.8
	Syrian Arab Rep.	MICS3	2006	98	98	98	0.3
	Tunisia	MICS3	2006	87	85	92	0.4
	Yemen, Republic	MICS3	2006	59	94	43	36
SSA	Angola	WHO	2006	43	79	7	54
	Benin	WHO	2001	0.8	2	0.1	94
	Botswana	WHO	2006	45	70	36	44
	Burkina Faso	MICS3	2006	3.9	13	0.2	94
	Burundi	MICS3	2005	0.1	0.2	0.1	99
	Cameroon	MICS3	2006	16	30	1.4	73
	Cape Verde	WHO	2006	63	86	28	35
	Central African Republic	MICS3	2006	0.1	0.1	0.02	99
	Chad	WHO	2003	2.1	3.4	0.9	88
	Comoros	WHO	2003	0.8	1.9	0.4	73
	Congo, Rep. of	WHO	2005	8.7	16	1.0	82

Region	Country	Source	Year	% all house-holds using LPG	% urban house-holds using LPG	% rural house-holds using LPG	% using solid fuels
	Côte d'Ivoire	MICS3	2006	14	—	—	86
	Ethiopia	WHO	2005	0.05	0.4	0.0	95
	Gabon	WHO	2006	68	80	23	27
	Gambia, The	MICS3	2005–06	2.5	4.6	0.6	91
	Ghana	MICS3	2006	10	20	2.5	86
	Guinea	WHO	2005	0.1	0.3	0.03	98
	Guinea-Bissau	MICS3	2006	0.2	0.4	0.05	98
	Kenya	HH surveys	2005–06	3.5	12	0.7	83
	Lesotho	WHO	2005	19	57	10	69
	Liberia	WHO	2006	0.07	0.2	0	99
	Madagascar	WHO	2004	0.8	2.4	0.4	99
	Malawi	MICS3	2006	0	0	0	99
	Mali	WHO	2006	0.4	1.4	0.04	98
	Mauritania	MICS3	2007	36	—	—	62
	Mauritius	WHO	2003	95	95	95	1.3
	Mozambique	WHO	2003	1.4	4.9	0.01	97
	Namibia	WHO	2006	2.5	4.2	1.0	56
	Niger	WHO	2006	0.7	3.4	0.1	99
	Nigeria	MICS3	2007	0.5	1.2	0.1	75
	Rwanda	WHO	2005	0.02	0.1	0	99
	São Tomé and Principe	MICS3	2006	23	32	11	76
	Senegal	WHO	2006	41	74	12	56
	Sierra Leone	WHO	2007	0.3	0.1	0	99
	Somalia	MICS3	2006	0.03	0.1	0	100
	South Africa	Statistics SA	2005–06	2.6	—	—	15
	Swaziland	WHO	2003	12	24	7.2	46
	Tanzania	WHO	2007	0.2	0.8	0	97
	Togo	MICS3	2006	1.2	2.6	0.2	98
	Uganda	HH surveys	2005–06	0.2	0.7	0	98
	Zambia	WHO	2007	0.01	0.02	0	85
	Zimbabwe	WHO	2003	0.5	1.5	0.08	67

Sources: WHO 2011; UNICEF various years for MICS3; World Bank various years for DHS; Bacon, Bhattacharya, and Kojima 2010 for HH (household) surveys; and Statistics South Africa 2008 for Statistics SA.
Notes: ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MNA = Middle East and North Africa; SSA = Sub-Saharan Africa; — = not available; + = no distinction made between natural gas and LPG, and hence the answer may apply to either fuel; * = total use across fuels greater than 100 percent, indicating that the question asked which fuels were used for cooking.

Table A1.2: Percentage of households using solid fuels as primary cooking fuel by quintile

Region	Country	Source	Q1	Q2	Q3	Q4	Q5
Asia	Bangladesh (2006)	MICS3	98	98	97	94	49
	Cambodia	HH surveys	99	99	98	97	76
	India	HH surveys	93	91	86	69	25
	Indonesia (2002–03)	DHS	95	70	39	12	1.1
	Lao PDR	MICS3	100	100	100	100	89
	Mongolia	MICS3	99	100	100	92	2
	Nepal (2001)	DHS	100	100	100	94	54
	Pakistan	This study	87	83	81	73	52
	Sri Lanka	This study	97	94	88	78	51
	Thailand	MICS3	90	56	27	5.4	0.4
	Vanuatu	MICS3	98	98	97	93	38
	Vietnam	MICS3	100	96	91	52	8.1
ECA	Albania	MICS3	97	85	71	34	0.9
	Armenia	DHS	70	32	17	6.3	0
	Belarus	MICS3	15	1.7	0	0	0
	Bosnia and Herzegovina	MICS3	95	79	48	15	0.4
	Georgia	MICS3	99	95	65	8.2	0
	Kazakhstan	MICS3	69	31	14	1.6	0
	Kyrgyz Republic	MICS3	77	60	52	17	0.3
	Macedonia, FYR	MICS3	78	55	42	11	2.9
	Montenegro	MICS3	83	53	21	2.8	0.1
	Serbia	MICS3	86	54	21	2	0.2
	Tajikistan	MICS3	75	46	38	27	2.3
	Turkmenistan	DHS	1.2	0	0.1	0	0
	Ukraine	MICS3	45	3.3	0	0	0
	Uzbekistan	MICS3	55	21	7.8	1.7	0.2
LAC	Belize	MICS3	25			0	
	Bolivia (2003)	DHS	99	66	10	0.9	0.2
	Colombia (2005)	DHS	84	20	1.8	0.4	0
	Dominican Republic	MICS related	53	5.8	1.1	0.2	0
	Guyana	MICS3	51	7.2	1.5	0	0
	Mexico	This study	48	19	10	3.8	1.0
	Nicaragua (2001)	DHS	100	98	84	40	3.2
	Peru	This study	72	57	32	14	3.9
	Suriname	MICS3	45	17	9	0.7	0.1
	Trinidad and Tobago	MICS3	1.4	0	0	0	0
MNA	Egypt, Arab Rep. (2000)	DHS	11	0.5	0	0	0
	Morocco*	DHS	34	12	2.3	0.1	0.1
	Syrian Arab Rep.	MICS3	1.4	0	0	0	0
	Yemen, Republic	MICS3	94	54	16	3.6	0.1
SSA	Benin (2001)	DHS	100	100	100	96	82
	Burkina Faso	MICS3	100	100	97	97	78

Region	Country	Source	Q1	Q2	Q3	Q4	Q5
	Burundi	MICS3	100	100	100	100	98
	Cameroon	MICS3	98	95	94	72	22
	Central African Republic	MICS3	100	100	99	99	97
	Côte d'Ivoire	MICS3	100	100	99	90	41
	Ethiopia	DHS	100	100	100	100	81
	Gabon (2000)	DHS	99	57	11	2.6	0.2
	Gambia, The	MICS3	100	98	95	86	79
	Ghana	MICS3	100	98	95	89	49
	Kenya	HH surveys	99	98	93	88	56
	Malawi	MICS3	100	100	100	100	94
	Mali (2001)	DHS	100	98	94	91	96
	Mauritania	MICS3	100	96	71	36	9.9
	Mozambique (2003)	DHS	100	100	100	88	17
	Namibia (2000)	DHS	100	80	53	30	0.8
	Nigeria	MICS3	99	97	94	67	22
	Rwanda (2000)	DHS	100	100	100	98	45
	São Tomé and Principe	MICS3	100	95	79	63	31
	Somalia	MICS3	100	100	100	99	99
	South Africa	Statistics SA	25	23	15	4.6	0.8
	Togo	MICS3	100	100	99	98	92
	Uganda	HH surveys	100	100	99	99	95
	Zambia (2001–02)	DHS	100	100	99	98	21

Sources: The sources are identical to those for Table 1.
Note: See the notes for Table 1.

Appendix 2: Survey descriptions, variable calculations, and additional data

The total household expenditure in each country is computed using a uniform procedure. Monthly total household expenditure is defined as the sum of the following components:

(1) Food expenditures. Expenditures for all food items using recall periods of varying lengths are prorated to a 30-day level.

(2) Imputed food expenditures. Imputed values of non-purchased but consumed food items from the recall period are prorated to a 30-day level.

(3) Non-food expenditures. Expenditures on non-food items are prorated to a 30-day level where required. Where both annual and monthly expenditures are available, the following practice is followed:

- Monthly. For expenditures on items such as fuel and light, entertainment, non-institutional medical, personal, toiletries, consumer services, rent, and commuting, the monthly recall values are used.
- Annual. Expenditures on such items as clothing, bedding, footwear, education, medical (institutional), durable goods, life insurance premiums, vehicle insurance premiums, and membership fees are prorated from their annual levels to 30-day levels.

The surveys provide information on certain large expenditure items (such as furniture; household appliances including refrigerators, air conditioners, washing machines, televisions, DVD players; expensive jewelry; automobiles; personal computers; ceremonies; and taxes and cesses). Expenditures on these items are removed for two reasons: first to avoid misrepresentation of households in their respective income quintiles since large expenditures are not made regularly, and second to enable cross-country comparison, given that the various categories of large expenditure items were treated differently (being included in some surveys but not in others). Where information is available, food items, both purchased and non-purchased, are deflated by a cost-of-living index defined for foodstuffs in order to remove geographical and temporal variations in the cost of living. Details of deflation procedures are included in the notes below on each country

The datasets are divided into five population quintiles based on monthly per capita expenditure levels derived from the above definition of total household expenditures. Each quintile contains the same number of *individuals* and not households. As well as national quintiles, separate urban and rural quintile groups are defined by drawing households from the national quintile, depending on whether they resided in an urban or rural area. The numbers of people in these quintile groups are no longer the same and depend on the relative numbers of urban and rural households in the nationally defined quintile. Both the quantity and implicit price data (for the first six countries) are examined for outliers and households with extreme values are excluded from analysis.

All the surveys contained some missing observations. Table A2.1 provides the numbers of observations at three levels:

1. The total number of households interviewed (full sample).

2. The number of households for which there is complete information on household weights, household size, and all expenditure items. This set of households is used to provide of the tabulations concerning the number of households using LPG, and their average expenditure (cleaned sample).
3. The number of households for which there is also complete information on all the variables used in the Heckman equations reported (Heckman sample). This number is divided into those purchasing LPG (selected) and those not purchasing LPG (censored).

Table A2.1: Sample size for countries analyzed

Country	Full	Cleaned	Heckman	LPG selection
Guatemala	13,686	13,656	13,185	5,830
India	124,644	120,427	108,003	35,806
Indonesia	10,575	9,928	8,942	651
Kenya	13,212	12,754	9,601	436
Pakistan	14,744	14,700	11,546	1,107
Sri Lanka	20,682	18,473	16,007	4,674
Albania	3,600	3,420	3,420	2,298
Brazil	55,970	43,435	34,116	31,310
Mexico	29,468	25,068	25,068	14,197
Peru	26,598	20,414	16,469	9,632

Source: Authors' calculations

Table A2.2 shows the total population (rural and urban) and the equivalent number of households at a national level based on the household weights.

Table A2.2: Population estimates based on returns from cleaned data sample in survey year

Country	Total national population	Total population, cleaned data			Total households, cleaned data			Sample households, cleaned data		
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Guatemala	1.30E+07	6.73E+06	6.24E+06	1.30E+07	1.22E+06	1.42E+06	2.64E+06	7,857	5,799	13,656
India	1.09E+09	7.10E+08	2.39E+08	9.49E+08	1.45E+08	5.49E+07	2.00E+08	76,783	43,644	120,427
Indonesia	2.19E+08	1.14E+08	9.18E+07	2.06E+08	2.89E+07	2.29E+07	5.18E+07	5,631	4,297	9,928
Kenya	3.63E+07	2.77E+07	6.68E+06	3.44E+07	5.08E+06	1.67E+06	6.75E+06	8,270	4,484	12,754
Pakistan	1.54E+08	8.87E+07	4.12E+07	1.30E+08	1.30E+07	6.21E+06	1.92E+07	8,894	5,806	14,700
Sri Lanka	1.99E+07	1.56E+07	2.73E+06	1.84E+07	3.89E+06	6.28E+05	4.51E+06	13,874	4,599	18,473
Albania	3.14E+06	1.56E+06	1.43E+06	2.99E+06	3.51E+05	3.98E+05	7.49E+05	1568	1,852	3,420
Brazil	1.93E+08	2.39E+07	1.17E+08	1.41E+08	6.56E+06	3.63E+07	4.28E+07	9768	33,667	43,435
Mexico	1.06E+08	1.96E+07	7.30E+07	9.26E+07	4.50E+06	1.84E+07	2.29E+07	5409	19,659	25,068
Peru	2.92E+07	9.96E+06	1.83E+07	2.82E+07	2.30E+06	4.42E+06	6.72E+06	8092	12,322	20,414

Sources: National population from WDI, others from authors' calculations.

Guatemala (ENCOVI 2006)

The data for this study are taken from the 2006 Living Standards Survey (ENCOVI) administered by the National Statistical Institute of Guatemala. The fieldwork for the survey was carried out between March and October. The survey did not provide information on items consumed but not purchased, except for food. The total non-purchased food was equivalent to 14

percent of total cash expenditure. Expenditures on all food and non-food items for rural households were deflated by an adjustment factor equal to 0.8695.

The questionnaire asked whether the household had consumed or purchased LPG in the previous month, and if so, how much was consumed or purchased. The survey did not distinguish between quantities purchased and quantities acquired free of charge for any of the fuels. Households were asked whether they used firewood for cooking, but were not asked about other fuels. Although LPG was used by 60 percent of households, many households made combined use of LPG and firewood for cooking. Use of kerosene, in contrast, was limited: only 11 percent of all households purchased kerosene, including 2 percent of LPG-purchasing households.

Table A2.3 shows the number of purchasing households and mean quantities of LPG purchased. The percentage of user households increased with quintile level and was particularly high in urban areas and exceeded 80 percent in the top two quintiles. Although 20-, 35-, 40-, and 100-pound cylinders are also available, the predominant cylinder size for residential customers is 25 pounds, or 11.4 kg, and this may be reflected in the survey returns on the amount purchased or consumed each month. In every quintile group the average purchasing household acquired about 11 kg in the previous month, suggesting that this question was widely interpreted as how much had been purchased, rather than how much had been used. In such a case it is possible that lower-income households did not refill every month, leading to their non-recording as LPG purchasers.

Table A2.3: Number of households purchasing LPG and average quantity purchased per month by purchasing households in Guatemala

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	4,262 (1.5)	9,504 (11)	13,766 (3.7)	11.2 (1.7)	11.0 (2.2)	11.1 (2.0)
2	23,966 (8.5)	57,841 (38)	81,807 (19)	10.0 (1.7)	11.2 (2.1)	10.8 (2.0)
3	57,387 (21)	168,716 (70)	226,103 (44)	11.1 (2.4)	11.4 (2.6)	11.3 (2.5)
4	100,584 (45)	320,473 (84)	421,057 (70)	11.2 (2.7)	11.4 (3.1)	11.4 (3.0)
5	103,736 (65)	496,231 (88)	599,967 (83)	10.7 (3.7)	13.2 (4.5)	12.8 (4.3)
All	289,935 (24)	1,052,765 (74)	1,342,700 (51)	10.9 (2.9)	12.2 (3.6)	11.9 (3.4)

Source: Authors' calculations.
Notes: The number of purchasing households is followed by the percentage of households in the quintile that purchased LPG in parentheses. The percentages are based on the total number of households in each rural quintile, urban quintile, and national quintile. The average quantity purchased in kg per month by purchasing households in each quintile is followed by the quantity purchased per person in parentheses.

Table A2.4 shows the share of total expenditure allocated to LPG averaged across all households—that is, averaged across all users and non-users—as well as for user households only. The share for all households increased—except in the top quintile—and the share for user households decreased with quintile level. The coefficient of variation of the calculated prices of LPG was 0.11 (based on household weights), indicating that 95 percent of prices were within 80 percent to 120 percent of the national average price.

Table A2.4: Shares of total household expenditure on LPG for all households and for purchasing households in Guatemala (%)

Quintile	All households			User households		
	Rural	Urban	Total	Rural	Urban	Total
1	0.1	0.8	0.2	6.2	6.8	6.6
2	0.3	1.7	0.8	4.1	4.4	4.3
3	0.8	2.5	1.6	3.8	3.6	3.7
4	1.3	2.3	1.9	2.8	2.7	2.8
5	1.0	1.4	1.3	1.6	1.6	1.6
All	0.6	1.8	1.3	2.7	2.5	2.5

Source: Authors' calculations.

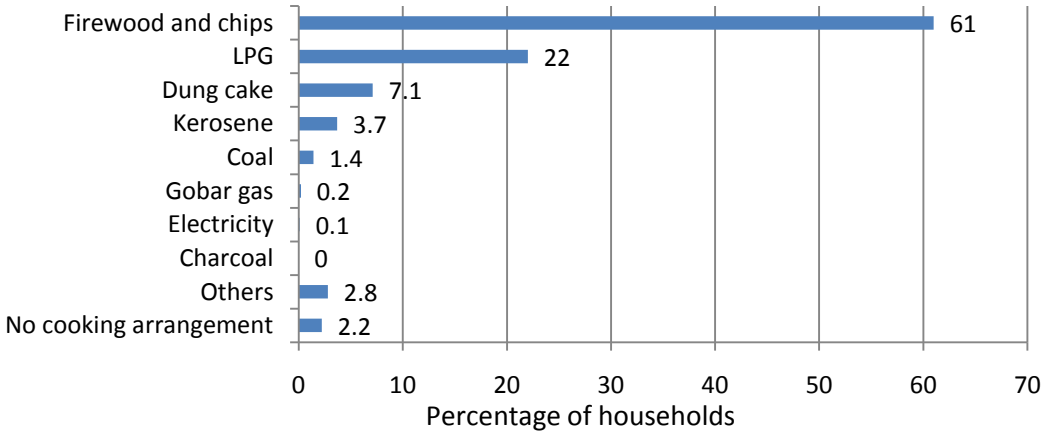
India (National Sample Survey, 2004–05)

The data are taken from the 61st round of the National Sample Survey of India administered by the government's National Sample Survey Organization. The fieldwork for the survey was carried out between July 2004 and June 2005.

The value of all non-purchased items was about 14 percent of total purchased expenditure, while non-purchased food accounted for about 82 percent of all non-purchased items. The former ratio tended to decline at the upper quintile levels. The latter was approximately constant across the quintile groups. The value of non-purchased non-food items may be underestimated, as the only expenditure values reported for non-purchased non-food items were fuel and lighting items and some durable goods. The expenditures on all items (both food and non-food items) were not deflated because adjustment factors were not available.

The household survey asked how much LPG the household had consumed in the previous 30 days, and also what the main cooking fuel was. Figure A2.1 shows the distribution of households by main energy source for cooking. LPG was the most common source of fuel after firewood and chips. Kerosene was used by a small proportion of the population, while electricity was scarcely used.

Figure A2.1: Main source of energy for cooking across all households in India



Source: Authors' calculations.

The percentage of households purchasing LPG was higher in urban than in the corresponding rural quintile and increased with quintile level (Table A2.5). Most households reporting positive consumption of LPG used it as the primary cooking fuel. The quantities purchased were also higher for urban quintiles and again increased with quintile level.

Table A2.5: Number of households purchasing LPG and average quantity purchased per month by purchasing households in India

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	112,425 (0.4)	21,550 (2.1)	133,975 (0.4)	7.3 (1.0)	9.6 (1.3)	7.6 (1.1)
2	674,055 (2.0)	243,925 (9.4)	917,980 (2.6)	7.7 (1.3)	9.6 (1.5)	8.2 (1.3)
3	2,120,861 (6.4)	1,160,992 (21)	3,281,853 (8.5)	8.6 (1.6)	10.6 (1.8)	9.3 (1.7)
4	5,366,497 (18)	5,350,249 (44)	10,716,746 (25)	8.8 (1.9)	11.5 (2.2)	10.2 (2.0)
5	8,482,313 (49)	25,548,510 (76)	34,030,823 (67)	9.5 (2.6)	12.3 (3.2)	11.6 (3.1)
All	16,756,151 (12)	32,325,226 (59)	49,081,377 (24)	9.1 (2.2)	12.1 (3.0)	11.0 (2.7)

Source: Authors' calculations.
Note: See notes for Table A2.3.

The shares of total expenditure allocated to LPG for all households increased with quintile level for both rural and urban groups, while the shares for user households decreased. The shares for urban user households were greater than for rural except for the highest-income group (Table A2.6). The coefficient of variation of the calculated prices of LPG was 0.09, indicating that 95 percent of prices were within 80–120 percent of the national average price.

Table A2.6: Shares of total household expenditure on LPG for all households and for purchasing households in India (%)

Quintile	All households			User households		
	Rural	Urban	Total	Rural	Urban	Total
1	0.0	0.2	0.0	6.9	8.0	7.0
2	0.1	0.7	0.2	6.3	7.0	6.5
3	0.4	1.4	0.5	6.0	6.9	6.4
4	0.9	2.6	1.4	5.2	5.9	5.5
5	2.0	2.9	2.6	4.0	3.8	3.9
All	0.5	2.5	1.1	4.8	4.3	4.5

Source: Authors' calculations.

Indonesia (SUSENAS, January Panel Module 2005)

The data are taken from the consumption module of the National Socio-Economic Survey (SUSENAS) administered by Badan Pusat Statistik-BPS Statistics Indonesia. The fieldwork for the survey was carried out between January and March 2005.

The value of all non-purchased items (food only) was about 12 percent of total purchased expenditure. The ratio tended to decline at the upper quintile levels. The survey did not distinguish between purchased and non-purchased values for non-food items except for housing. The data were not deflated because adjustment factors were not available.

The survey did not ask about cooking fuels and had only one question on energy sources—the quantity and amount spent on the fuel in the previous month and in the past 12 months, except for firewood where no quantity was reported. At the lower quintiles, very few households purchased LPG and scaling up to national numbers is likely to be subject to large statistical uncertainty. LPG was moderately used only at the highest urban quintile level. The quantities purchased per household were comparable both across quintiles and between rural and urban households. Per capita consumption, however, tended to be larger in rural areas where households were smaller than in urban areas in each quintile (Table A2.7).

Table A2.7: Number of households purchasing LPG and average quantity purchased per month by purchasing households in Indonesia

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	3,808 (0.1)	9,142 (0.7)	12,950 (0.2)	15.0 (2.5)	12.0 (0.2)	12.9 (0.9)
2	24,637 (0.3)	0 (0.0)	24,637 (0.3)	10.2 (1.8)	No users	10.2 (1.8)
3	88,127 (1.4)	97,511 (2.4)	185,638 (1.8)	9.6 (2.3)	11.7 (2.2)	10.7 (2.3)
4	185,614 (3.6)	385,297 (6.6)	570,911 (5.2)	10.8 (3.0)	11.3 (2.4)	11.1 (2.6)
5	330,909 (11)	2,532,273 (27)	2,863,182 (24)	12.1 (3.5)	12.3 (3.2)	12.2 (3.3)
All	633,095 (2.2)	3,024,223 (13)	3,657,318 (7.1)	11.3 (3.1)	12.1 (3.1)	12.0 (3.1)

Source: Authors' calculations.
Note: See notes for Table A2.3.

The share of total spending allocated to LPG by user households was higher for rural quintiles than for the corresponding urban quintile, but did not show any clear trend across income levels, possibly because of the small number of purchasers in the lower quintiles (Table A2.8). The coefficient of variation for the calculated prices of LPG was 0.16, indicating that 95 percent of prices were within 70–130 percent of the national average price.

Table A2.8: Shares of total household expenditure on LPG for all households and for purchasing households in Indonesia (%)

Quintile	All households			User households		
	Rural	Urban	Total	Rural	Urban	Total
1	0.0	0.0	0.0	4.4	1.5	2.4
2	0.0	0.0	0.0	3.6	No users	3.6
3	0.1	0.1	0.1	4.0	3.6	3.8
4	0.1	0.2	0.2	4.0	3.2	3.5
5	0.3	0.6	0.5	2.8	2.1	2.2
All	0.1	0.3	0.2	3.4	2.3	2.5

Source: Authors' calculations.

Kenya (KIHBS 2005–2006)

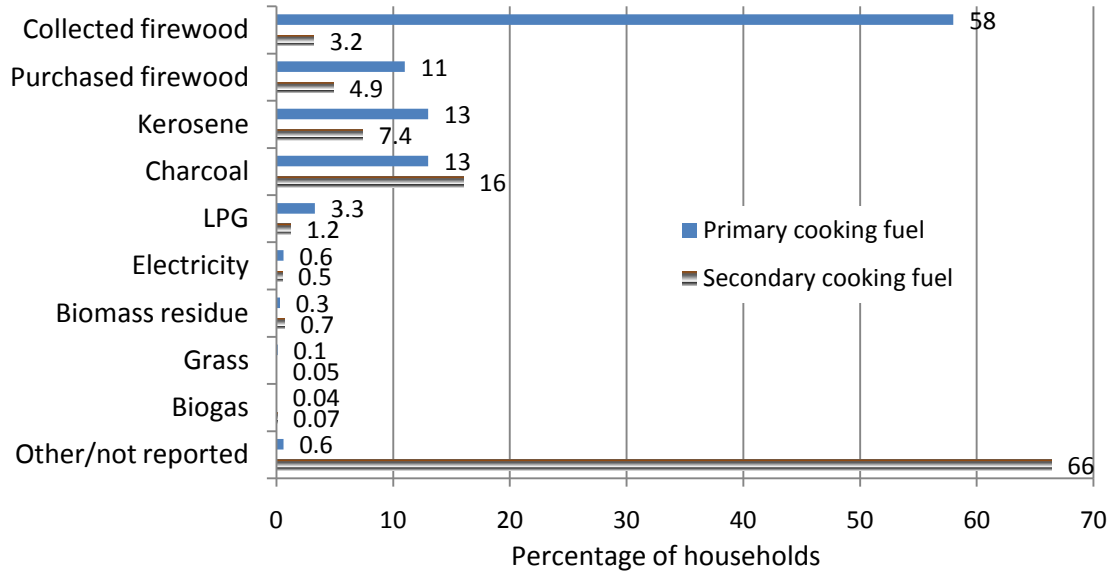
The data are from the Kenya Integrated Household Budget Survey (KIHBS) administered by the Kenya National Bureau of Statistics (Ministry of Planning and National Development) of the Government of Kenya. The fieldwork for this survey was carried out between May 2005 and April 2006. The total of all non-purchased items (both food and others) was imputed to be equivalent to 51 percent of total cash expenditure. However, about 95 percent of non-purchased

items were foodstuffs for every quintile group. Expenditures on all food items were deflated using a Laspeyres index provided in the survey data set.

The survey asked a wide range of questions concerning fuel use, allowing an unusually rich picture of LPG use:

1. What is the main primary type of appliance used for cooking? The options include a gas cooker.
2. What are the household's main and secondary sources of cooking fuel? Collected firewood was the most commonly used cooking fuel, followed by kerosene and charcoal. The secondary choice of fuel for cooking was not identified by two thirds of households, but kerosene and charcoal were the most frequently cited alternatives (Figure A2.2).
3. In the last year, has your household used LPG?
4. During the last month, how many units of LPG did you use? Units are defined by a range of specified cylinder sizes. This question elicited an integer for every response, suggesting that the respondents might have cited the number of cylinders the household had in operation (or possibly owned) during the recall period rather than an estimate of the actual amount of LPG consumed. Table A2.9 summarizes the data on the distribution of LPG cylinder use by size in kg and quintile group. LPG use was almost entirely confined to the top quintile. The spread of cylinder sizes used was relatively even and suggests that households could vary their choice of cylinder to suit their convenience and budget. Households reporting the cylinder size used also reported the prices paid. The unit price was highest for the smallest cylinder size, as expected, but for other sizes there was no trend with relation to size.
5. What was the cost of those units that you used during the last month?
6. During the last month how much (expenditure and quantity) was purchased of LPG?

Figure A2.2: Main sources of energy for cooking across all households in Kenya



Source: Authors' calculations.

Table A2.9: Number of households using cylinders of different sizes and average household monthly expenditures on LPG (in Kenyan shillings)

Cylinder size	3 kg		6 kg		12.5 kg		13 kg		15 kg	
Quintile	Exp.	N	Exp.	N	Exp.	N	Exp.	N	Exp.	N
1	—	0	—	0	—	0	—	0	—	0
2	—	0	—	0	—	0	—	0	—	0
3	5,880	427	13,279	749	—	0	11,714	264	13,198	434
4	13,613	963	18,424	5,610	13,784	1,588	12,966	240	—	0
5	42,864	44,892	41,319	84,210	56,164	28,677	78,329	56,498	88,977	30,909
TOTAL	**41,914**	**46,282**	**39,669**	**90,569**	**53,940**	**30,265**	**77,745**	**57,002**	**87,928**	**31,343**

Source: Authors' calculations.
Notes: Exp. = expenditure on LPG; N = number of households; — = not applicable.

Table A2.10 summarizes the number of positive responses to each question and provides an indication of the variation in the number of LPG users according to different criteria. The Heckman model presented in section 4.3 defines user households based on criterion 6 in Table A2.10, and the three additional models discussed correspond to criteria 2, 3, and 5. In each case, the number entering the Heckman model is smaller than the number shown in the second column because some of the users were missing data for one or more variables in the two equations. When averaged across quintile groups, the amount purchased per month per household was about 10 kg, equivalent to 2.5 kg per person, in both urban and rural areas (Table A2.11).

Table A2.10: Number of LPG-users in Kenya by various indicators

Parameter	Users in sample[a]	Users in population[b]
1. Number of households using LPG cooker as primary cooking unit	487	212,235
2. Number of households where LPG was primary or secondary cooking fuel	668	304,668
3. Number of households using LPG in last year	837	381,049
4. Number of households indicating cylinder size used in last month	716	329,218
5. Number of households indicating total cost of cylinders used in last month	736	336,042
6. Number of households indicating expenditure on purchase of LPG in last month	570	268,862

Source: Authors' calculations.
a. Raw data, unadjusted for household weights.
b. Data adjusted using household weights.

Table A2.11: Number of households purchasing LPG and average quantity purchased per month by purchasing households in Kenya

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	0 (0.0)	0 (0.0)	0 (0.0)	—	—	—
2	876 (0.1)	0 (0.0)	876 (0.1)	4.2 (0.5)	—	4.2 (0.5)
3	1,383 (0.1)	447 (0.2)	1,830 (0.1)	6.3 (0.9)	2.2 (1.0)	5.3 (0.9)
4	7,203 (0.6)	3,637 (1.1)	10,840 (0.7)	4.8 (0.8)	6.9 (1.2)	5.5 (0.9)
5	49,516 (5.4)	205,800 (20)	255,316 (13)	11.0 (2.8)	9.6 (2.6)	9.9 (2.6)
All	58,978 (1.2)	209,884 (13)	268,862 (4.0)	10.0 (2.5)	9.6 (2.5)	9.7 (2.5)

Source: Authors' calculations.
Notes: See notes for Table A2.3. — = not applicable.

The share of total expenditure allocated to LPG by user households declined with quintile level except for the top rural quintile (Table A2.12). The coefficient of variation for the prices of LPG was 0.23, indicating that 95 percent of prices were within 50–150 percent of the mean price.

Table A2.12: Shares of total household expenditure on LPG for all households and for purchasing households in Kenya (%)

Quintile	All households			User households		
	Rural	Urban	Total	Rural	Urban	Total
1	0.00	0.00	0.00	0.0	0.0	0.0
2	0.01	0.00	0.00	5.8	0.0	5.8
3	0.01	0.02	0.01	5.3	8.7	6.1
4	0.02	0.06	0.03	3.7	5.4	4.3
5	0.25	0.53	0.40	4.6	2.6	3.0
All	0.05	0.34	0.12	4.5	2.7	3.1

Source: Authors' calculations.

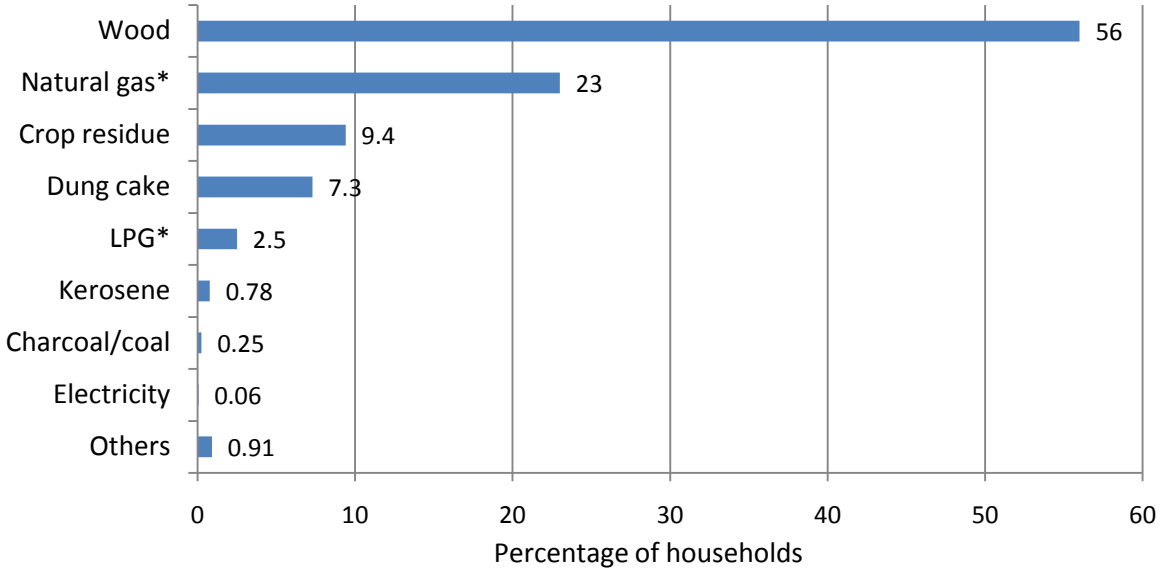
Pakistan (HIES 2004–2005)

The data are from the 2004–2005 Household Integrated Economic Survey (HIES), administered by the Federal Bureau of Statistics of the Government of Pakistan. The fieldwork for this survey was carried out between July 2004 and June 2005.

Non-purchased items had an average value of 37 percent of cash expenditure, and non-purchased food accounted for about one third of all non-purchased items. Both ratios were approximately constant across the expenditure distribution. All expenditures on food items were deflated using a Paasche index provided in the survey data set.

The questionnaire asked three separate questions related to the use of LPG. The first two were related to the source of energy for cooking and lighting, respectively, but the categories of possible replies aggregated natural gas (piped gas) and LPG (bottled gas). The third question asked whether the household had consumed any LPG during the previous month and, if so, how much the household had paid and consumed. There was a separate question on the expenditure on natural gas. The availability of natural gas as a household fuel complicates the analysis because natural gas is a superior fuel for cooking and is a clear substitute for LPG. Combining responses from different parts of the survey showed that the number of households who had purchased LPG was considerably larger than the number of LPG-purchasing households that reported that gas (in some form) was their primary cooking fuel. Households may have used LPG as a secondary cooking fuel or for other purposes, but only 0.7 percent used it as the primary lighting source. As expected, few households purchased both natural gas and LPG. Firewood was the most commonly used primary fuel for cooking, while electricity, charcoal, and kerosene were scarcely used as the primary cooking source (Figure A2.3).

Figure A2.3: Main source of energy for cooking across all households in Pakistan



Source: Authors' calculations.
Note: * = estimated by splitting gas users into piped gas and LPG users based on fuel purchase patterns (very few purchased both).

In both rural and urban areas, the purchase of LPG increased with quintile level (Table A2.13). The uptake of LPG was notably higher in rural than in urban areas at the highest quintile, reflecting the widespread use of natural by higher-income urban households. The quantity purchased increased with quintile level, and urban households consumed more on average. The dominant cylinder size for residential customers is 11.8 kg. For all but the top quintile, the quantity consumed was less than the content of one cylinder, suggesting that respondents indeed reported what the household consumed, rather than purchased. However, LPG is sold illegally in smaller unauthorized cylinders and through decanting from legal-size cylinders. Because these transactions are illegal, the amounts sold for less than 11.8 kg at a time are not known. The coefficient of variation of prices was 0.11, indicating that 95 percent of prices were within 80–120 percent of the national average price.

Table A2.13: Number of households purchasing LPG and average quantity purchased per month by purchasing households in Pakistan

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	68,373 (2.8)	20,650 (3.3)	89,023 (2.9)	3.0 (0.3)	5.4 (0.6)	3.6 (0.4)
2	122,554 (4.8)	39,931 (4.9)	162,485 (4.8)	3.8 (0.5)	6.0 (0.8)	4.4 (0.5)
3	196,654 (7.2)	74,687 (7.5)	271,341 (7.3)	5.0 (0.6)	7.2 (1.2)	5.6 (0.8)
4	274,347 (9.9)	103,759 (7.8)	378,106 (9.2)	6.5 (1.0)	9.0 (1.4)	7.2 (1.1)
5	431,426 (17)	196,419 (8.0)	627,845 (13)	9.3 (1.9)	15.8 (2.8)	11.4 (2.2)
All	1,093,354 (8.4)	435,446 (7.0)	1,528,800 (7.9)	6.8 (1.2)	11.3 (1.9)	8.1 (1.4)

Source: Authors' calculations.
Note: See notes for Table A2.3.

The expenditure share of LPG for all households increased in both urban and rural quintile, while the share for urban user households remained almost constant. The share for rural user households actually increased with quintile level (Table A2.14).

Table A2.14 : Shares of total household expenditure on LPG for all households and for purchasing households in Pakistan (%)

Quintile	All households			User households		
	Rural	Urban	Total	Rural	Urban	Total
1	0.1	0.1	0.1	2.5	4.4	2.9
2	0.1	0.2	0.1	2.6	4.4	3.0
3	0.2	0.4	0.2	2.8	4.9	3.4
4	0.3	0.3	0.3	3.3	4.4	3.6
5	0.6	0.4	0.5	3.3	4.6	3.7
All	0.3	0.3	0.3	3.1	4.6	3.5

Source: Authors' calculations.

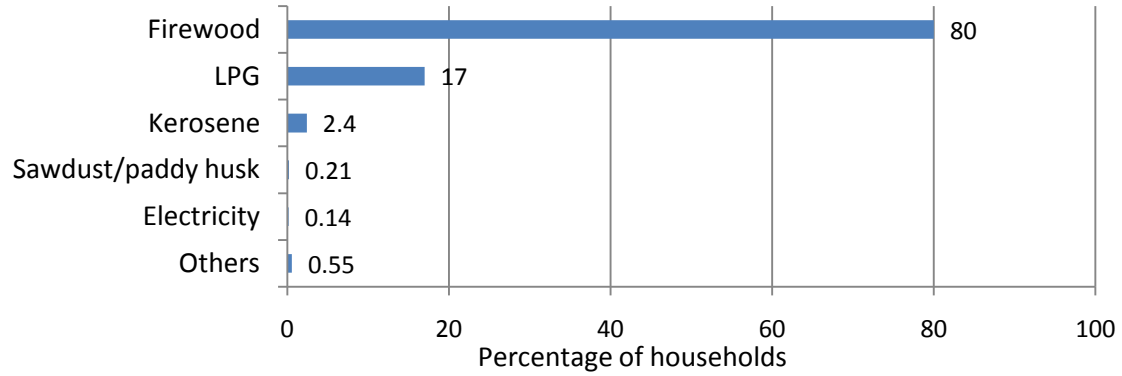
Sri Lanka (HIES 2006–2007)

The data are taken from the 2006–2007 Household Income and Expenditure Survey (HIES) administered by the Department of Census and Statistics in the Ministry of Finance and Planning of the Government of Sri Lanka. The fieldwork for the survey was carried out between July 2006 and June 2007.

The value of all non-purchased items was about 18 percent of total purchased expenditure, while non-purchased food accounted for about 25 percent of all non-purchased items. These ratios were nearly constant across quintile groups. All expenditures on food items were deflated using a Laspeyres index provided in the survey data set.

The questionnaire asked about the average expenditure on and quantity of LPG purchased in a month as well as the household's primary cooking fuel. Twenty-six percent of households reported LPG purchase in the previous month while 17 percent named LPG as their primary cooking fuel. Firewood was the most commonly cited primary cooking fuel (Figure A2.4), even in the top quintiles. According to a separate question, 83 percent of households collected some firewood and a quarter of households purchased it.

Figure A2.4: Main source of energy for cooking across all households in Sri Lanka



Source: Authors' calculations.

For those reporting LPG purchase, the proportion of households using LPG was considerably higher in urban areas and increased steadily in both rural and urban areas with quintile level, with more than four fifths of urban households in the top quintile reporting LPG purchase. The amount purchased per household and per capita increased with quintile level, and was higher in urban than in rural areas in each quintile (Table A2.15). Cylinder sizes of 2.3, 5, and 12.5 kg were available and offered flexibility to households in different circumstances. The coefficient of variation was 0.07 with 95 percent of prices falling within 85–115 percent of the national average price, suggesting that unit prices did not vary much with the cylinder size or by location.

Table A2.15: Number of households purchasing LPG and average quantity purchased per month by purchasing households in Sri Lanka

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	10,774 (1.5)	5,270 (13)	16,044 (2.1)	5.9 (0.9)	8.6 (1.1)	6.8 (1.0)
2	41,490 (5.4)	16,833 (27)	58,323 (7.0)	6.0 (1.2)	8.0 (1.4)	5.6 (1.2)
3	106,465 (14)	41,016 (39)	147,481 (17)	6.1 (1.3)	8.3 (1.6)	6.7 (1.4)
4	204,554 (25)	89,543 (59)	294,097 (31)	6.1 (1.5)	8.9 (2.0)	7.0 (1.6)
5	439,585 (54)	221,908 (83)	661,493 (61)	7.2 (2.2)	9.8 (2.9)	8.1 (2.4)
All	802,868 (21)	374,570 (60)	1,177,438 (26)	6.7 (1.8)	9.3 (2.4)	7.5 (2.0)

Source: Authors' calculations.
Note: See notes for Table A2.3.

The share of total household expenditure allocated to LPG averaged across all households increased, and that for user households decreased, with quintile level (Table A2.16).

Table A2.16: Shares of total household expenditure on LPG for all households and for purchasing households in Sri Lanka (%)

Quintile	All households			User households		
	Rural	Urban	Total	Rural	Urban	Total
1	0.1	0.5	0.1	3.6	4.2	3.8
2	0.2	0.9	0.2	2.9	3.6	3.1
3	0.3	1.2	0.4	2.5	3.1	2.6
4	0.5	1.6	0.7	2.0	2.7	2.2
5	0.8	1.6	1.0	1.5	1.9	1.6
All	0.4	1.4	0.5	1.8	2.3	2.0

Source: Authors' calculations.

Albania (LSMS 2008)

The data are taken from the Living Standards Measurement Survey (LSMS) 2008 administered by the Institute of Statistics (INSTAT) in the Republic of Albania. The fieldwork for the survey was carried out between June 2008 and August 2008.

The value of all non-purchased items was about 17 percent of total purchased expenditure, while non-purchased food accounted for about 83 percent of all non-purchased items. The former ratio tended to decline at the upper quintile levels. The latter was

approximately constant across the quintile groups. All food items were deflated by an index provided in the survey data set.

The survey asked whether households used LPG and how much they paid per month on average. The survey asked what LPG and electricity were used for but did not have a question on the main cooking fuel. Monthly average retail prices of LPG from four main suppliers were available and the expenditure on LPG recorded in the previous month (May through July, 2008) was divided by the national average price for that month to estimate the quantity purchased by each household.

At least two thirds of households in each quintile group used LPG except the bottom rural quintile. The share of households using LPG peaked in the middle quintiles and then declined. Although not shown in the table, among households not using LPG for cooking, the proportion using electricity for cooking increased with quintile level: for the bottom rural quintile only 31 percent used electricity instead, while for the top urban quintile 89 percent used electricity for cooking. The quantity purchased per capita steadily increased with quintile level, and the quantity per household also generally increased, except for the top quintile in rural areas (Table A2.17).

Table A2.17: Number of households purchasing LPG and estimated average quantity purchased per month by purchasing households in Albania

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	38,983 (56)	30,621 (71)	69,604 (62)	8.4 (1.5)	10.5 (2.3)	9.3 (1.9)
2	48,167 (67)	37,851 (68)	86,018 (68)	9.7 (2.0)	10.1 (2.6)	9.9 (2.2)
3	53,483 (74)	57,190 (80)	110,673 (77)	10.1 (2.5)	12.0 (3.3)	11.1 (2.9)
4	58,524 (80)	68,869 (75)	127,393 (77)	13.3 (3.5)	12.7 (4.0)	12.9 (3.7)
5	50,371 (79)	91,561 (67)	141,932 (71)	11.9 (4.2)	13.0 (5.1)	12.6 (4.8)
All	249,528 (71)	286,092 (72)	535,620 (71)	10.9 (2.8)	12.1 (3.8)	11.5 (3.4)

Source: Authors' calculations.
Note: See notes for Table A2.3.

The expenditure share of LPG averaged across all households declined steadily in urban areas and also declined from the fourth to the top quintile in rural areas. The expenditure share was higher in urban areas in all cases except the top quintile. For user households, the expenditure share generally declined with quintile level (Table A2.18).

Table A2.18: Shares of total household expenditure on LPG for all households and for purchasing households in Albania (%)

Quintile	All households			User households		
	Rural	Urban	Total	Rural	Urban	Total
1	1.7	3.3	2.4	3.1	4.7	3.8
2	1.9	2.5	2.1	2.8	3.6	3.1
3	2.0	2.9	2.4	2.7	3.6	3.2
4	2.3	2.4	2.4	2.9	3.2	3.1
5	1.9	1.8	1.8	2.3	2.7	2.5
All	2.0	2.4	2.2	2.8	3.3	3.1

Source: Authors' calculations.

Brazil (POF 2008–2009)

The data are taken from the 2008–2009 Consumer Expenditure Survey (POF) administered by the Brazilian Institute of Geography and Statistics (IBGE). The fieldwork for the survey was carried out between May 2008 and May 2009.

The value of all non-purchased items was about 11 percent of total purchased expenditure, while non-purchased food accounted for about 20 percent of all non-purchased items. These ratios tended to decline at the upper quintile levels. The fullest set of data provided by the survey had deflated all items.

The questionnaire asked a single question concerning LPG: the expenditure during the previous 90 days. The survey also asked for expenditures on a range of other sources of energy, without specifying what these were used for or distinguishing between purchased and freely acquired. The Ministry of Energy publishes annual average retail prices in the country's 27 regions (ANP 2010), and this study used the national average price for 2008 and 2009 of 2.66 reais per kg. The coefficient of variation (not adjusted for regional populations) across regional average retail prices was 0.2, indicating that 95 percent of prices were within 60–140 percent of the national average, possibly reflecting size of Brazil and the need of retail prices to reflect internal transport costs. As long as these price variations were weakly correlated with the variations in survey variables, the bias in the selection and consumption equations would still be small, but the calculated quantities consumed could have large measurement errors.

Brazil exhibited a much higher selection rate of LPG than other countries studied, recording a national average uptake rate of 88 percent of households (Table A2.19). LPG was used by the great majority of households at all income levels in both rural and urban areas. The share of households using LPG increased with income level in rural areas but fell from 90–95 percent to less than 80 percent in the top urban quintile. Nationally, of the 6 million households that had not purchased LPG during the 90 days of the survey period, 1 million had paid for natural gas. Of the nearly 38 million households that had purchased LPG, only 75,000 had also paid for natural gas. Of the households not using LPG in the top urban quintile, 99 percent were connected to electricity and 41 percent to natural gas. In the top rural quintile of non-LPG users, 79 percent were connected to electricity but none to natural gas. Although there is no information on the choice of fuel for cooking, these numbers suggest that the highest-income households had switched to natural gas, if available, or electricity for cooking. LPG is sold in 2-, 13-, 20-, and

45-kg cylinders in the country, with 13 kg being the most common cylinder size. The estimated quantity purchased per user household per month was about 8 kg, suggesting that households on average refill 13-kg cylinders twice every three months or so. On a per household basis, Brazil was the only country where the quantity of LPG purchased declined steadily with quintile level in urban areas. The actual amounts purchased (which was not reported) might not have followed the same pattern if, for example, prices paid by high-income urban households had been lower than those paid by low-income households.

Table A2.19: Number of households purchasing LPG and estimated average quantity purchased per month by purchasing households in Brazil

Quintile	Number of purchasing households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	1,324,705 (69)	3,626,484 (90)	4,951,189 (83)	7.5 (1.8)	8.9 (2.1)	8.5 (2.0)
2	1,249,814 (83)	5,528,346 (95)	6,778,160 (92)	8.0 (2.4)	8.9 (2.5)	8.7 (2.5)
3	1,171,781 (87)	6,676,602 (95)	7,848,483 (94)	8.3 (2.8)	8.5 (2.8)	8.5 (2.8)
4	970,943 (89)	8,017,543 (93)	8,988,486 (93)	8.1 (3.3)	8.2 (3.2)	8.2 (3.2)
5	614,433 (90)	8,506,101 (79)	9,120,534 (80)	8.5 (4.2)	8.1 (3.7)	8.1 (3.7)
All	5,331,676 (81)	32,355,076 (89)	37,686,852 (88)	8.0 (2.7)	8.4 (3.0)	8.4 (2.9)

Source: Authors' calculations.
Note: See notes for Table A2.3.

The average expenditure shares of LPG declined sharply with quintile level for each category of households examined (Table A2.20). For the lowest-income user households, the expenditure share was more than 6 percent.

Table A2.20: Shares of total household expenditure on LPG for all households and for purchasing households (percent) in Brazil

Quintile	All households (% of total expenditure)			User households (%)		
	Rural	Urban	Total	Rural	Urban	Total
1	4.6	5.8	5.4	6.6	6.5	6.5
2	3.0	3.4	3.3	3.6	3.6	3.6
3	2.2	2.4	2.4	2.6	2.5	2.5
4	1.6	1.6	1.6	1.8	1.7	1.8
5	1.0	0.7	0.7	1.1	0.9	0.9
All	2.9	2.3	2.3	3.5	2.5	2.7

Source: Authors' calculations.

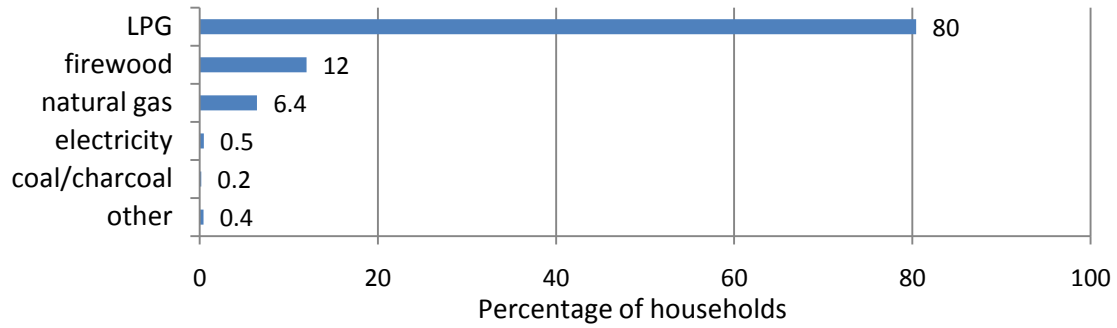
Mexico (ENIGH 2008)

The data are taken from the 2008 National Household Income and Expenditure Survey (ENIGH) conducted by the National Institute of Statistics and Geography (INEGI) in Mexico. The fieldwork for the survey was carried out between August and November 2008.

The value of all non-purchased items was about 30 percent of total purchased expenditure, while non-purchased food accounted for about 62 percent of all non-purchased items. These ratios were approximately constant across the quintile groups. Expenditures were not deflated because adjustment factors were not available.

The questionnaire asked about the main cooking fuel and about the expenditure on LPG during the previous month. LPG was by far the most commonly used fuel, followed by firewood and natural gas (Figure A2.5). As expected, virtually no households purchased both LPG and natural gas.

Figure A2.5: Main source of energy for cooking across all households in Mexico



Source: Authors' calculations.

LPG is sold in 10-, 15,- 20-, 30- and 45-kg cylinders to residential consumers, with the last three being the most common sizes. Cylinder sales accounted for about half of LPG sold to residential consumers in 2007 (Mexico, Ministry of Energy 2008). Instead of cylinders, many middle- and high-income households have large tanks—typically 300 liters in capacity (about 165 kg)— installed on rooftops, which are refilled by LPG delivery trucks. Apartment complexes can also have large tanks serving multiple households. Prices are independent of cylinder and tank sizes.

The relatively large sizes of cylinders and tanks commonly used in Mexico appear to have resulted in many LPG-using households reporting zero expenditure in the previous month: 80 percent of households reported that LPG was their primary cooking fuel, but only 60 percent had purchased it in the previous month. The 4.8 million households that cited LPG as their main cooking fuel but had not purchased it presumably represents those who had bought large quantities of LPG but not in the month preceding the survey. Because of this large discrepancy, data on LPG as the primary cooking fuel are used in the selection equation. The quantities of LPG purchased were estimated for the survey period from the expenditure information using national average LPG prices (published by the energy ministry) for the month prior to that in which the survey was administered to the various households.

Quantities of LPG purchased in Mexico were markedly higher than in other countries. Household consumption was slightly larger in urban than in rural areas (Table A2.21). In each quintile, household size was smaller in rural than in urban areas—by as much as 20 percent in the top quintile—making rural per capita consumption of LPG larger.

Table A2.21: Number of households using LPG and estimated average quantity purchased per month by purchasing households in Mexico

Quintile	Number of user households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	533,300 (32)	1,341,636 (77)	1,874,936 (56)	22.7 (4.4)	23.5 (4.3)	23.3 (4.4)
2	600,786 (55)	2,514,017 (88)	3,114,803 (79)	24.1 (5.9)	25.5 (5.6)	25.2 (5.7)
3	587,654 (66)	3,222,272 (91)	3,809,926 (86)	25.1 (7.1)	26.3 (6.7)	26.1 (6.8)
4	431,773 (78)	4,003,896 (91)	4,435,669 (90)	27.8 (9.3)	29.5 (8.4)	29.3 (8.5)
5	278,910 (90)	4,913,026 (84)	5,191,936 (84)	30.5 (14.5)	37.0 (13.6)	36.7 (13.7)
All	2,432,423 (54)	15,994,847 (87)	18,427,270 (80)	25.2 (7.3)	30.0 (8.9)	29.3 (8.6)

Source: Authors' calculations.
Note: See notes for Table A2.3. User households exceeded purchasing households by 4.8 million.

The expenditure share of LPG for purchasing households was high for the lowest quintiles and higher for rural than urban households (Table A2.22). The expenditure shares averaged across all households under-estimate the actual shares because millions of user households appear to have reported no purchase during the survey period.

Table A2.22: Shares of total household expenditure on LPG for all households and for purchasing households in Mexico (%)

Quintile	All households			Purchasing households		
	Rural	Urban	Total	Rural	Urban	Total
1	2.0	3.7	2.8	7.5	6.9	7.1
2	2.9	3.7	3.5	5.9	5.6	5.6
3	2.9	3.1	3.1	5.1	4.7	4.8
4	2.6	2.7	2.7	4.6	4.1	4.1
5	2.4	1.9	1.9	3.9	3.1	3.2
All	2.5	2.8	2.7	5.6	4.4	4.6

Source: Authors' calculations.

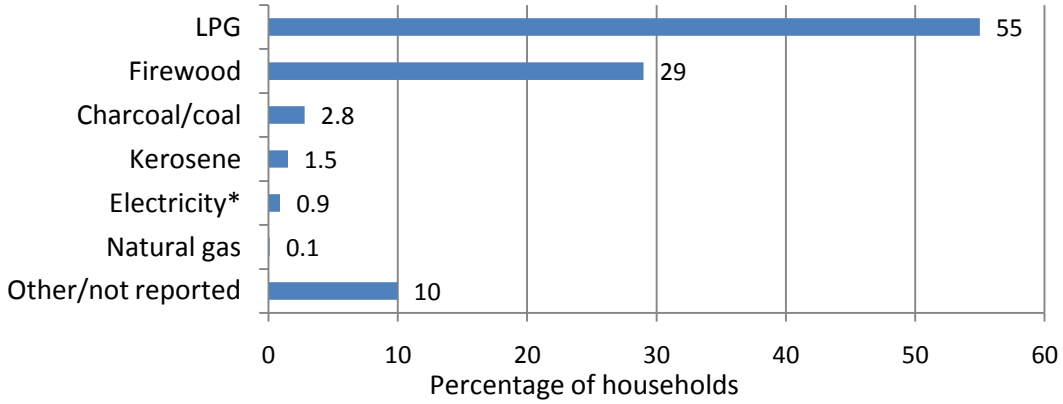
Peru (ENAHO 2009)

The data are taken from the 2009 National Household Survey on Living Conditions and Poverty (ENAHO) administered by the National Institute of Statistics and Information (INEI) in Peru. The fieldwork for the survey was carried out between January 2009 and December 2009.

The value of all non-purchased items was about 33 percent of total purchased expenditure, while non-purchased food accounted for about 53 percent of all non-purchased items. These ratios tended to decline at the upper quintile levels. All food expenditures were deflated using adjustment factors provided in the survey data set.

The survey asked households to report the primary energy source for cooking. LPG was the primary cooking fuel for more than half of the households surveyed, followed by firewood (Figure A2.6). Although 84 percent of households was connected to electricity, as in other countries, very few households cooked primarily with electricity.

Figure A2.6: Main source of energy for cooking across all households in Peru



Source: Authors' calculations.

In addition, the survey asked as a series of questions on LPG use:

1. Did you use LPG last month? 11,747 respondents (corresponding to 4.22 million households) replied yes.
2. Did you use any LPG for cooking last month? 11,747 replied yes.
3. How much did you spend on LPG last month? 11,555 (4.15 million households) reported positive expenditures.
4. What is your primary cooking fuel? 10,095 (3.73 million households) answered that LPG was the primary cooking fuel.

These answers indicate that 1.6 percent of LPG users had not purchased LPG in the previous month, and that 88 percent of households using LPG used it as the primary cooking fuel. Only a handful of households used natural gas.

The national average retail price of LPG for 2009 of 3.242 nuevos soles per kilogram obtained from ECLAC (2010) was used to calculate estimates of quantities purchased by households based on their expenditure. LPG is sold to residential consumers in 10-kg cylinders in Peru. The rate of selection of LPG in urban areas was similar to the very high rate observed in Brazil, but was markedly lower in rural areas, especially at the lower quintiles (Table A2.23). The quantities purchased per household per month were slightly higher than in Brazil, while the per capita amounts were slightly lower.

Table A2.23: Number of households using LPG and estimated average quantity purchased per month by purchasing households in Peru

Quintile	Number of user households (percent)			Kg purchased per household (per capita)		
	Rural	Urban	Total	Rural	Urban	Total
1	50,837 (5.5)	79,367 (40)	130,204 (12)	6.3 (1.4)	8.6 (1.8)	7.7 (1.6)
2	125,742 (18)	365,296 (70)	491,038 (40)	7.5 (1.8)	9.1 (2.0)	8.7 (1.9)
3	132,221 (35)	761,581 (85)	893,802 (70)	8.0 (2.2)	9.7 (2.2)	9.5 (2.2)
4	110,440 (53)	1,082,078 (92)	1,192,518 (86)	8.7 (2.8)	9.8 (2.5)	9.7 (2.5)
5	61,001 (62)	1,448,440 (89)	1,509,441 (88)	8.7 (3.8)	9.6 (3.1)	9.6 (3.2)
All	480,241 (21)	3,736,762 (85)	4,217,003 (63)	7.9 (2.4)	9.6 (2.6)	9.4 (2.6)

Source: Authors' calculations.
Note: See notes for Table A2.3.

The expenditure share of LPG, averaged across all households, was low and did not exceed 2.5 percent (Table A2.24). For user households, however, the expenditure share reached 6 percent for the lowest quintile in urban areas. The share declined with quintile level for both rural and urban users.

Table A2.24: Shares of total household expenditure on LPG for all households and for purchasing households (percent) in Peru

Quintile	All households (% of total expenditure)			User households (%)		
	Rural	Urban	Total	Rural	Urban	Total
1	0.2	2.5	0.7	4.5	6.3	5.6
2	0.6	2.3	1.3	3.1	3.2	3.2
3	0.9	2.1	1.8	2.6	2.5	2.5
4	1.1	1.8	1.7	2.1	2.0	2.0
5	1.0	1.1	1.1	1.7	1.2	1.3
All	0.6	1.7	1.3	2.7	2.0	2.1

Source: Authors' calculations.

Appendix 3: Modeling household uptake and use of LPG

Heckman's approach to sample selection distinguishes between (1) the decision on whether to use LPG (probit-type selection equation); and (2) the decision on how much LPG to use, conditional on having decided to use it (consumption equation). Because the user group has been selected by the first-stage equation, the possibility of selection bias would be introduced if a standard regression were used at the second stage. The two-step approach to estimating the Heckman model (Hoffman and Kassof 2005) is to construct a variable from the first stage, the inverse Mills' ratio, which measures the degree of correlation between independent variables and the error term producing an omitted-variable bias. Entering this variable into the second stage, together with the specified explanatory variables, enables consistent estimates of the parameters to be obtained.

For identification of the consumption equation, it is generally recommended that the selection equation contain at least one variable not included in the former. However, because the Mills' ratio is a non-linear combination of the selection variables, this condition is not strictly necessary. In practice the study did not experience near-singularity in the estimation of the consumption equation. The significance of the Mills' ratio in the second stage indicates whether there would have been selection bias in its absence. If the Mills' ratio is insignificant, a simple regression of the quantity of LPG on explanatory variables based on user households alone would be unbiased.

Where the number of households in the consumption equation is not the same as that in the selection equation (Mexico, Peru, and three out of four cases in Kenya), this study follows a two-step procedure: first a probit estimation for all households that yields estimated Mills' ratios for each household, and second a regression equation for the user households containing the inverse Mills' ratio as an explanatory variable.

If user households are the same in the selection and consumption equations, it is possible to estimate the two equations jointly using a maximum likelihood approach. The Mills' ratio is not directly utilized but instead the correlation (rho) between the errors in the selection and consumption equations is estimated. If rho is not significantly different from zero, there is no evidence of selection bias and the equations could have been estimated separately. Whichever procedure is used, estimation uses robust standard errors, thus allowing for possible heteroskedasticity.

The second-stage equation provides both a direct effect and an indirect effect of a change in an independent variable. The first comes from the coefficient of the variable estimated by the Heckman approach, while the indirect effect comes from the effect of a change in that variable on the correlation (rho) by the coefficient of rho in the second equation. The sum of the two effects is the conditional effect of a change in the independent variable at a given probability of using LPG, typically evaluated at the means of the independent variables. However, the increase in independent variable also increases the probability that the household will use LPG, and hence will increase its purchase through this route. The sum of this effect and the conditional effect is termed the unconditional effect, which shows the combined effect on the logarithm of the quantity of LPG consumed in kilogram per person in this paper. The results of Hoffman and

Kassouf (2005) provide some further insights on the conditional and unconditional marginal effects:

1. If a variable enters the first-stage but not the second-stage equation, there is no direct effect and the sign of the conditional effect will depend on the sign of the correlation (rho) between the error terms in the two equations. Where rho is positive, this results in the signs of the variables identified in the first stage being reversed in the calculation of the conditional marginal effect. In section 4.3, where conditional and unconditional marginal effects are calculated, Guatemala, Pakistan, and Sri Lanka had positive values for the rho.
2. If a variable enters the second-stage but not the first-stage equation the value of its conditional effect will be identical to that estimated in the second-stage equation (there is no indirect effect).

Appendix 4: Codes for education level attained by household members

Value	Guatemala	India	Indonesia	Kenya	Pakistan
0	No education	Not literate	No school	No education or pre-school	No education or less than Class 1
1	Pre-school	Literate without formal schooling	Pre-school education	Primary - STD 1	Class 1
2	Primaria -grade 1	Literate but below primary	elementary grade 1	Primary - STD 2	Class 2
3	Primaria -grade 2	Primary	elementary grade 2	Primary - STD 3	Class 3
4	Primaria -grade 3	Middle	elementary grade 3	Primary - STD 4	Class 4
5	Primaria -grade 4	Secondary	elementary grade 4	Primary - STD 5	Class 5
6	Primaria -grade 5	Higher secondary	elementary grade 5	Primary - STD 6	Class 6
7	Primaria -grade 6	Diploma/certificate course	elementary grade 6	Primary - STD 7	Class 7
8	Basico -grade 1	Graduate	Junior high grade 1	Primary - STD 8	Class 8
9	Basico -grade 2	Postgraduate and above	Junior high grade 2	Secondary - FORM 1	Class 9
10	Basico -grade 3		Junior high grade 3	Secondary - FORM 2	Class 10
11	Diversificado -grade 1		Senior high grade 1	Secondary - FORM 3	F.A/F. Sc/C. Com/Diploma
12	Diversificado -grade 2		Senior high grade 2	Secondary - FORM 4	B.A./ B. Sc.
13	Diversificado -grade 3		Senior high grade 3	Secondary - FORM 5	M.A./ M.Sc.
14	Superior -grade 1		Vocational school grade 1	Secondary - FORM 6	D. Phil/Ph.D
15	Superior -grade 2		Vocational school grade 2	University - UNIV 1	
16	Superior -grade 3		Vocational school grade 3	University - UNIV 2	
17	Superior -grade 4		Diploma I/II grade 1	University - UNIV 3	
18	Superior -grade 5		Diploma I/II grade 2	University - UNIV 4	
19	Superior -grade 6		Diploma III grade 1	University - UNIV 5 & above	
20	Postgrado -grade 1		Diploma III grade 2		
21	Postgrado -grade 2		Diploma III grade 3		
22	Postgrado -grade 3		University grade 1		
23	Postgrado -grade 4		University grade 2		
24	Postgrado -grade 5		University grade 3		
25			University grade 4		
26			Master/Doctoral		

Value	Sri Lanka	Albania	Brazil	Mexico	Peru
0	No education	No education	No education	No education	No education
1	Grade 1	Primary year 1	1 year of education	1 year of education	1-year pre-school education
2	Grade 2	Primary year 2	2 years of education	2 years of education	2-year pre-school education
3	Grade 3	Primary year 3	3 years of education	3 years of education	3-year pre-school education
4	Grade 4	Primary year 4	4 years of education	4 years of education	1-year primary education
5	Grade 5	Primary year 5	5 years of education	5 years of education	2-year primary education
6	Grade 6	Primary year 6	6 years of education	6 years of education	3-year primary education
7	Grade 7	Primary year 7	7 years of education	7 years of education	4-year primary education

Value	Sri Lanka	Albania	Brazil	Mexico	Peru
8	Grade 8	Primary year 8 or 9	8 years of education	8 years of education	5-year primary education
9	Grade 9	secondary year 1	9 years of education	9 years of education	6-year primary education
10	Grade 10	Secondary year 2	10 years of education	10 years of education	1-year secondary education
11	G.C.E. (O/L) or equivalent	Secondary year 3	11 years of education	11 years of education	2-year secondary education
12	Grade 12	Secondary year 4	12 years of education	12 years of education	3-year secondary education
13	G.C.E. (A/L) or equivalent	Vocational year 1	13 years of education	13 years of education	4-year secondary education
14	G.A.Q./G.S.Q.	Vocational year 2	14 years of education	14 years of education	5-year secondary education
15	Degree	Vocational year 3	15 + years of education	15 years of education	1-year higher education (no university)
16	Post graduate degree/diploma	Vocational year 4		16 years of education	2-year higher education (no university)
17		Vocational year 5		17 years of education	3-year higher education (no university)
18		University year 1		18 years of education	4-year higher education (no university)
19		University year 2		19 years of education	5-year higher education (no university)
20		University year 3		20 years of education	1-year higher education (university)
21		University year 4		21 years of education	2-year higher education (university)
22		University year 5		22 years of education	3-year higher education (university)
23		University year 6		23 years of education	4-year higher education (university)
24		Post-graduate year 1			5-year higher education (university)
25		Post-graduate year 2			6-year higher education (university)
26		Post-graduate year 3			7-year higher education (university)
27		Post-graduate year 4			1-year post-graduate education
28		Post-graduate year 5			2-year post-graduate education

Notes: G.C.E. = General certificate of education; O/L = ordinary level; A/L = advanced level. G.A.Q. = graduate arts qualification (1st year university); G.S.Q. = graduate science qualification (1st year university); F.A. = faculty of arts 1st year intermediate certificate; F.Sc. = faculty of science 1st year intermediate qualification; C.Comm. = certificate in commerce.

References

ANP (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis). 2010. Anuário Estatístico 2010. www.anp.gov.br/

Bacon, Robert, Soma Bhattacharya, and Masami Kojima. 2009. *Changing Patterns of household expenditures on energy: A case study of Indonesia and Pakistan*. Extractive Industries for Development Series #6. Washington DC: World Bank. http://siteresources.worldbank.org/INTOGMC/Resources/eifd6_changing_household_patterns.pdf

———. 2010. *Expenditure of Low-Income Households on Energy: Evidence from Africa and Asia*. Extractive Industries for Development Series #16. Washington DC: World Bank. http://siteresources.worldbank.org/EXTOGMC/Resources/336929-1266963339030/eifd16_expenditure.pdf

Barnes, Douglas, Kerry Krutilla, and William Hyde. 2005. *The Urban Household Energy Transition*. Washington DC: Resources for the Future.

Blundell, Richard and Costas Meghir. 1987. "Bivariate Alternatives to the Tobit Model." *Journal of Econometrics* 1987 (1–2): 179–200.

Business Standard. 2005. "Cooking gas waitlist to be cleared by month-end." Dec. 28.

Deaton, Angus. 1997. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*. Washington DC: World Bank.

Deaton, Angus and Margaret Irish. 1984. "Statistical models for Zero Expenditures in Household Budgets." *Journal of Public Economics* 23(1): 59–80.

ECLAC (Economic Commission for Latin America and the Caribbean). 2010. "Fuels in South America Plus Mexico." http://websie.eclac.cl/sisgen/ConsultaIntegrada.asp?idAplicacion=19&idioma=i

ESMAP (Energy Sector Management Assistance Program). 2003a. "Household Fuel Use and Fuel Switching in Guatemala." ESMAP Report 27274. Washington DC: World Bank. http://go.worldbank.org/4O2TDUA9K0

———. 2003b. "India: Access of the Poor to Clean Household Fuels." ESMAP Report 263. Washington DC: World Bank. http://go.worldbank.org/RO5BWUED10

FAO (Food and Agricultural Organization). 2009. *The State of the World's Forest*. Rome. ftp://ftp.fao.org/docrep/fao/011/i0350e/i0350e.pdf

Farsi, Mehdi, Massimo Filippini, and Shonali Pachauri. 2005. "Fuel Choices in Urban Indian Households." CEPE Working Paper 42. Centre for Energy Policy and Economics, Swiss Federal Institutes of Technology.

Gupta, Gautam and Gunnar Köhlin. 2006. "Preferences for Domestic Fuel: Analysis with Socio-economic Factors and Rankings in Kolkata, India." *Ecological Economics* 57(1): 107–121.

Heckman, James. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47(1): 153–61.

Hoffman, Rodolfo and Ana Kassouf. 2005. "Deriving Conditional and Unconditional Marginal Effects in Log Earnings Equations Estimated by Heckman's Procedure." *Applied Economics*: 37 (11), 1303–1311.

IEA (International Energy Agency). 2010. *World Energy Outlook 2010*. Paris.

Israel, Debra. 2002. "Fuel Choice in Developing Countries: Evidence from Bolivia." *Economic Development and Cultural Change* 50(4): 865–889.

Kojima, Masami. *Government Response to Oil Price Volatility: Experience of 49 Developing Countries*. Extractive Industries for Development Series #10. Washington DC: World Bank.

Masera, Omar, Barbara Saatkamp, and Daniel Kammen. 2000. "From Linear Fuel Switching to Multiple Cooking Strategies: a Critique and Alternative to the Energy Ladder Model." *World Development* 28 (12): 2083–2103.

Mekonnen, Alemu and Gunnar Köhlin. 2008. "Determinants of Household Fuel Choice in Major Cities in Ethiopia." Environment for Development Discussion Paper. August: EfD DP 08–18.

Mexico, Ministry of Energy. 2008. "Liquefied Petroleum Gas Market Outlook 2008–2017." www.energia.gob.mx/res/PE_y_DT/pub/LPG%20Outlook%202008-2017.pdf

PREDAS (Programme for the Promotion of Household and Alternative Energy Sources). 2009. "Women and household energy in Sahelian countries." *Boiling Point* 56. www.hedon.info/docs/BP56_PREDAS.pdf

Pundo, M. and G. Fraser. 2006. "Multinomial Logit Analysis of Household Cooking Fuel Choice in Rural Kenya: The Case of the Kisumu District." *Agrekon* 45 (1): 24–37.

Rajakutty, S., Masami Kojima, V. Madhava Rao, Kumpatla Jayalakshmi, D.P.R. Reddy, Suman Chandra, V. Annamalai, and Nagaseshna. 2002. "Promoting Clean Household Fuels Among the Rural Poor: Evaluation of the Deepam Scheme in Andhra Pradesh." South Asia Region Internal Discussion Paper, World Bank. http://siteresources.worldbank.org/INTOGMC/Resources/promoting_clean_household_fuels.pdf

Statistics South Africa. 2008. "Statistical Release P0100. Income and expenditure of households 2005/2006." www.statssa.gov.za/publications/P0100/P01002005.pdf

UNDP (United Nations Development Programme) and WHO (World Health Organisation). 2009. *The Energy Access Situation in Developing Countries. A Review Focusing on the Least Developed Countries and Sub-Saharan Africa.* http://www.who.int/indoorair/publications/energyaccesssituation/en/index.html

UNICEF. Various years. Multiple Indicator Cluster Survey 3: Monitoring the Situation of Children and Women. www.childinfo.org/mics3_surveys.html

U.S. EIA (Energy Information Administration). 2011. "Petroleum and other liquids: data." Online database. www.eia.gov/petroleum/data.cfm

WDI (World Development Indicators). World Bank online database. http://data.worldbank.org/data-catalog/world-development-indicators/wdi-2010

WHO (World Health Organization). 2002. *The World Health Report 2002: Reducing Risks, Promoting Healthy Life*. Geneva. www.who.int/whr/2002/en/

———. 2011. WHO Household energy database. www.who.int/indoorair/health_impacts/he_databasecont/en/index.html

Wooldridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, Massachusetts: MIT Press.

World Bank. 2003. "Pakistan: Oil and Gas Sector Review." Report No. 26072-PK. Washington DC. http://go.worldbank.org/Z9FI8G4600

———. 2010a. "Subsidies in the Energy Sector: An Overview." A background paper for the World Bank Group energy sector strategy. Washington DC. http://siteresources.worldbank.org/EXTESC/Resources/Subsidy_background_paper.pdf

———. 2010b. "Consultations on energy with poor communities – Ayakope." http://siteresources.worldbank.org/EXTESC/Resources/Ayakope_Web_version.pdf?resourceurlname=Ayakope_Web_version.pdf

———. Various years. "Socio-economic differences in health, nutrition, and population within developing countries: Individual country reports." http://go.worldbank.org/T6LCN5A340